Resilience and Frailty in Older Adults: from Conceptual Understanding to Practical Intervention

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February 2020

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Abstract

Resilience is considered the polar opposite of frailty, in that frailty is defined as a loss of resilience reserved, and the ability of our bodily systems to repair themselves, to respond to trauma and infection, and maintain homeostasis in bodily systems. Resilience is also considered a physiological construct. This may be reflective of the reluctance to move away from considered resilience in solely physiological terms. However, recognition of non-physiological frailty is increased, and so too should more importance be given to psychological resilience. However, research examining the relationship between psychological resilience and frailty is lacking.

This study contains a total of six studies across five chapters. Chapter 1 evaluates current models of frailty and assessment tools and considers what tool is necessary to assess resilience. Chapter 1 also considers our conceptual understanding of resilience in the context of frailty, identifies gaps within our conceptualisations, and outlines how this research will attempt to address these issues. Chapter 2 (consisting of three studies) redefines and develops a frailty index into a holistic tool, identifying a psychosocial and environmental frailty marker and integrating them into assessment. Chapter 3 analytically considers the validity of our conceptual models of resilience in the context of frailty and determines the benefits of maintaining high levels of resilience directly on frailty, as well as frailty outcomes. Chapter 3 then proceeds to co-create an intervention designed to improve psychological resilience in older adults. Chapter 4 implements and evaluates the effectiveness of the resilience-building intervention. Finally, Chapter 5 provides a general discussion of principal findings within this thesis, and offers direction for future research.

Keywords: Resilience, Frailty, Loneliness, Age-Friendly Environment, Intervention

Acknowledgements

Firstly I would like to thank my supervisors for their contributions: Prof Adrian Burgess for his invaluable statistical education and support in ensuring all analytical work was completed to the highest of quality; Dr Lou Atkinson for her excellent support in developing my qualitative skills and aiding in the direction of all qualitative work; and Prof Carol Holland for giving me the opportunity to undertake such an exciting thesis, and for working diligently and selflessly with me throughout this thesis, and for developing me into the researcher I have become.

I also acknowledge the significant effect of my colleague Professor Mike Boulton for his guidance in the early stages of my development and opportunity to work in the field of resilience research.

I would like to acknowledge my colleagues in the Aston Research Centre for Healthy Ageing who offered a very welcoming environment on my arrival, and making me feel part of the Aston family.

I would also pay thanks to the contribution of my participants, particularly those residing in ExtraCare Retirement Villages, for making my work fun, enjoyable, and most importantly, possible.

I would like to thank my dearest friends, Paul Martin Jnr, James Gill, Philip Moore, and Steven Jackson for their humorous nature and for supporting me throughout my thesis.

I would also pay special tribute to my partner Anna Gilleen, for her unwavering support throughout this thesis. For selflessly being available and offering help and advice whenever it was needed.

Finally, I would like to express my gratitude to my dad for his guiding me into becoming the person I am today, for teaching me the values of respect and hard work, and to always strive to be better. The greatest man I have ever known, and one who will always have my respect.

This thesis was funded by The ExtraCare Charitable Trust and by the School of Life and Health Sciences at Aston University.

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List of Abbreviations

ACE-III	Addenbrooke's Cognitive Examination-III
ADL	Accumulation of Deficits
AFEAT	Age-Friendly Environment Assessment Tool
ANOVA	Analysis of Variance
ARCHA	Aston Research Centre for Healthy Ageing
CASP12	Control, Autonomy, Self-Realization, Pleasure scale (12-item)
CDRISC-10	Connor-Davidson Resilience Scale (10-item)
CSHA	Canadian Study of Healthy Ageing
eFI	electronic Frailty Index
EFS	Edmonton Frail Scale
FI36	Frailty Index (36-item)
FI38	Frailty Index (38-item)
FI48	Frailty Index (48-item)
FI49	Frailty Index (49-item)
FI52	Frailty Index (52-item)
FLP	Functional Limitations Profile
FP	Frailty Phenotype
GFI	Groningen Frailty Index
HADS	Hospital Anxiety and Depression Scale

HADS_A	Hospital Anxiety and Depression Scale (Anxiety)
HADS_D	Hospital Anxiety and Depression Scale (Depression)
IADL	Instrumental Activities of Daily Living
ICC	Intra Class Correlation
IFI52	Imputed Frailty Index (52-item)
KMO	Kaiser Meyer Olkin
MEPS	Mean-Ends Problem-Solving
MMSE	Mini Mental State Examination
PCA	Principal Components Analysis
RMSE	Root Mean Square Error
SPSS	Statistical Package for the Social Science
TFI	Tilburg Frailty Indicator
TUG	Timed Up-and-Go
UCLA	University of California, Los Angeles
WBA	Well-Being Assessment
WHO	World Health Organisation

Chapter 1

Literature Review

1.1. Introduction

According to the Office for National Statistics, from 2006 to 2016 the average life expectancy of the UK population has increased from 78.86 years to 79.17 years for men, and 81.24 years to 82.86 years for women, and this trend has continued (Morgan, 2019) i.e. people are living longer. This can be attributed to a greater awareness and implementation of healthy lifestyles, and the advancements in medicine and practices to the extent that previously fatal illnesses and diseases are now manageable and/or treatable. Improvements in occupational and environmental health also contribute to this. Although functional decline is inevitable, these improvements can help delay the process of functional decline until very old age is reached. During the process of decline, medical practice, including palliative care, helps manage this process of decline, although medical professionals still perceive frailty to be a diagnosis or category and not a measure that can reduce or worsen or is amenable to intervention. This has resulted in an increased variability in health and functioning through older age (Collard *et al.*, 2012). Yet, the improvements outlined fail to consider why such a variation in frailty exists. Indeed, whilst health resources available are likely to vary for individuals living in different communities, it is unlikely to account such a variation in health and functioning, which according to Collard *et al* (2012) ranges from 4% to 16% in adults aged 65 and over. One possibility is the varying levels of resilience in individuals.

According to Cosco *et al* (2017), resilience is the capacity for an individual to maintain functioning, and recover from a stressor. Resilience is a lifelong and dynamic process, and is influenced by stressors experienced and therefore is likely to vary between older adults (Keyes, 2004). Early indications show that resilience does provide a unique input into how well adults maintain functioning (Whitson *et al.*, 2016), which would explain the variation in frailty alluded to by Collard *et al* (2012). However, this understanding is founded on the conceptualisation that resilience is a physiological construct, yet resilience also possesses a

significant psychological contingent (Fletcher, & Sarkar, 2013) which is overlooked in this conceptualisation. According to Holland, Garner, & Gwyther (2018) psychological resilience (defined as a process of coping and adaptation, Cosco *et al.,* 2017) may provide a unique contribution to frailty that is separate from the physiological component, but also stated that further research into the relationship between psychological resilience and frailty is required. Therefore the aim of this chapter is to critically evaluate and review the concepts of frailty and resilience with a view to developing an integrated theory of both concepts that can be used to promote healthy ageing.

1.2. Frailty

Frailty, sometimes referred to as a lack of resilience reserves (Hicks & Miller, 2011), is a multidimensional, pre-disability syndrome conceptualized by a heightened state of vulnerability to adverse outcomes such as illness or injury (Clegg, Young, Iliffe, Rikkert & Rockwood, 2013; Markle-Reid & Browne, 2003). That is, frail individuals are those who are not only more susceptible to stressors such as an illness or injury, but who also tend to have more severe and negative outcomes with longer recovery times than robust/resilient individuals (Strandberg, Pitkälä & Tilvis, 2011). Frailty is characterised by a process of gradual decline, from being robust to functionally limited, over an extended period of time (Apòstolo *et al.,* 2017), although there is also the possibility of unexpected and drastic deterioration (Conroy, 2009; Morley, 2013). Frailty is also recognised as a predisposition to loss of independence, with an increased risk of hospitalisation, institutionalisation and death (Boyd *et al.,* 2005; Fried, Ferrucci, Darer, Williamson & Anderson, 2004; Rockwood, Mitnitski, Song, Steen & Skoog, 2006).

Initially, frailty was considered a natural and inevitable part of the ageing process, that the physiological changes over time predispose older adults to frailty (Pel-Littel, Schuurmans, Emmelot-Vonk & Verhaar, 2008). However, the recognition that frailty is more than a physiological construct, and is affected significantly by psychological, social, and environmental factors, referred to as frailty dimensions, has changed the contemporary understanding of frailty (Moorhouse & Rockwood, 2012). There is, however, a reluctance to expand our focus beyond a physiological standpoint and to consider frailty from a holistic perspective (Lally, & Crome, 2007). Yet it could be argued that this reductionist approach has also provided misconceptions about frailty. For instance, Conroy (2009) stated that frailty possesses the capacity for unexpected and drastic deterioration, yet is this because frailty is unpredictable, or that only one of multiple dimensions (physical, cognitive, psychological, social, and environmental frailty dimensions) is being assessed? That what is conceptualised as a sudden and unexpected decline may be deterioration in dimensions of frailty not being assessed having an adverse impact on health.

Frailty is no longer viewed as an inevitable outcome of the ageing process. As Bortz (1993) explains, whilst frailty is associated with age, not all older adults are frail and some older adults are able to maintain their functioning despite the physiological changes that predispose deterioration (Pel-Littlel *et al.,* 2008). There is also a general consensus that frailty is not a fixed process, but is dynamic, fluctuates, and can be reversed irrespective of age. This is referred to as the malleability of frailty (Morley, 2013). However, interventions attempting to demonstrate this phenomenon by reversing frailty have so far been inconsistent. For instance, a systematic review of 33 frailty interventions across 21 studies by Apóstolo *et al* (2018) found mixed results. Interventions either had no effect on frailty, or only provided short-term benefits.

The lack of improvement supports theories that frailty cannot be reversed (Puts, Shekary, Widdershove, & Heldens, 2009; Roland, Theou, Jakobi, Swan, & Jones, 2011), and that the improvements observed is a natural fluctuation of frailty (Campbell, & Buchner, 1997) which, according to Stolz, Mayerl, and Friedl (2019) can fluctuate up to 8% in the frailest older adults over a 6-month period with any change to health (this translated to a change of .10 under the accumulation of deficits model Stolz *et al* used). Furthermore, as many interventions are implemented as a response to a trauma, such as a hip fracture (Lally, & Crome, 2007), the improvement to frailty in these situations could be attributed to the natural process of healing over time as opposed to the intervention. Despite this, Apostolo *et al* (2018) did discover some effective interventions, those which were formed around physical activity, and greater improvements were observed in physical interventions which also incorporated a nutrition and/or cognitive component (Gustafsson *et al.,* 2012). Perhaps these findings justify the overutilization of physiological markers in defining, characterising, and assessing frailty. However, it is also plausible that predominantly using physical measures in this manner predisposes bias towards interventions oriented to physical improvement. That is, if frailty markers assessed are predominantly physiological (as is the case in clinically used tools such as the Frailty Phenotype (Fried *et al.,* 2001) and the frailty index derived from the Canadian Study of Healthy Ageing (CSHA, Rockwood *et al.,* 2005)), it is unsurprising that physiological frailty interventions are the most effective in combatting frailty progression. This is highlighted with 14 of the 21 studies reviewed by Apostolo *et al* (2018) assessing frailty using physiological assessments only. Despite this, these findings by Apostolo *et al* (2018) have confirmed that frailty is malleable, but have also highlighted the difficulty in manipulating this malleability to reverse frailty progression on a long-term basis. It is possible that whilst frailty progresses overall, interventions and recovery from crises support serve to delay progress, albeit temporarily, back along the frailty trajectory. This is highlighted in a

report by Holland *et al* (2017) which shows moving into ExtraCare retirement villages helped reduce frailty severity over the first two years of residents moving in, but by the 4th year of residence, frailty severity returned to baseline levels.

It could be argued that what is absent from the interventions reviewed is an underlying process of behavioural change to help participants incorporate the programme behaviour(s) into their daily routine post-intervention to help maintain benefits long-term. Indeed if such a process was implemented this could allow interventions to act both as preventative and treatment measures for older adults as the behaviour(s) that improve frailty could be incorporated into lifestyle before frailty progresses. However, there would be an emphasis on early intervention to maximise effectiveness as participants would be more capable of changing behaviour (Van Kan *et al.*, 2008).

Despite consensus on the conceptualisation and malleability of frailty, a similar consensus on how to operationalize it has yet to be reached. Rodriguez-Manas *et al* (2013), gave 33 health experts two sets of statements, one set defining frailty, and the other frailty diagnostic criteria, and asked them if they believed the statements accurately defined/diagnosed frailty. They found that there was unanimous agreement on only 44% of statements defining frailty and 19% of statements diagnosing frailty. This lack of consensus is also reflected in epidemiological research, with prevalence of frailty being estimated at anywhere between 4% and 17% of adults aged over 65 with between 19% and 53% of individuals being categorised as frail or pre-frail respectively (Collard, Boter, Schoevers & Oude Voschaar, 2012). Given that at least 29 indices of frailty have been developed (Dent, Kowal & Hoogendijk, 2016), each with their own interpretation of how best to assess frailty, along with a set of guidelines for building a new indices (Searle, Mitnitski, Gahbauer, Gill & Rockwood, 2008), such variability in estimating prevalence is unsurprising. This is highlighted by Collard *et al* (2012) who reviewed differences in frailty prevalence in 10 different indices across 21 studies and

confirmed that between these indices frailty prevalence in participants varied from 4.0% to 59.1%. Whilst some variation is expected, such a degree of variation cannot solely be attributed to different cohorts being used in the studies. Indeed Collard *et al* (2012) stated that the varying definitions of frailty were the primary cause for this variation.

It does, unfortunately, limit our ability to draw conclusions from a much of contemporary research in the area. Indeed, in many cases this definitional confusion has meant that meaningful conclusions drawn under one conceptualisation of frailty are not replicable or meaningful under another (Collard *et al.*, 2012). Despite this caveat, two definitions of frailty have emerged that are generally accepted by researchers and clinicians, both of which have been used as the basis of clinical frailty assessment tools. One defines frailty as a phenotype (Fried *et al.*, 2001), and the other defines frailty as an accumulation of impairments and illnesses (Rockwood & Mitnitski, 2007).

1.2.1. Frailty as a Phenotype

The Frailty Phenotype, developed by Fried *et al* (2001), defines frailty along a single physiological phenotype of loss of muscle mass and density, which is often attributed to sarcopenia (Fried, Ferrucci, Darer, Williamson & Anderson, 2004), and is characterised by a series of physical markers: unintentional weight loss (4.5kg or more over a 12 month period), self-reported feelings of exhaustion, low physical activity (equating to burning less than 270kcal/week for woman and 360kcal/week for men via exercise), slow walking speed, and weak muscle strength (often measured as grip strength or lower leg extension strength). Using this definition, the Frailty Phenotype model of assessment was developed, which examines for the presence of each of the five physical markers to determine frailty severity. Under this model, the presence of no markers is categorised as 'robust', the presence of one or two

markers is categorised as 'pre-frail', and 3 or more markers is categorised as 'frail'. The Frailty Phenotype is commonly used within clinical settings due to its ease of reproducibility, time-efficiency and strong prognostic capabilities in relation to predicting risk of hospitalisation, institutionalisation, and mortality over a 5-year period (Fried *et al.*, 2001; 2004).

However, by exclusively examining only physiological markers of frailty, the Phenotypic approach offers a reductionist conceptualisation of frailty assessment that has all the limitations of such an approach as previously outlined. Nor does that tool consider measures of functioning or well-being, both of which are part of frailty and predictors of the same outcomes (Clegg *et al.*, 2013; Gale, Cooper, Deary, & Sayer, 2014). Such limitations are illustrated by findings showing that the predictive capabilities of the Frailty Phenotype can be improved by incorporating an evaluation of cognitive ability into the assessment (Avila-Funes *et al.*, 2009). Furthermore, the scoring system of the Frailty Phenotype is poor at assessing meaningful change. For example, an individual who possesses four frailty markers prior to an intervention and only three markers post-intervention, therefore showing significant improvement in one of the markers, would be categorised as 'frail' in both instances, yet significant improvement would have occurred.

1.2.2. Frailty as an Accumulation of Deficits

The second conceptualisation of frailty derives from Rockwood's (2005) Accumulation of Deficits definition. In this, frailty is a conceived of as an accumulation of impairments and/or illnesses, and the more impairments and/or illnesses an individual lives with, the more severe frailty is (Rockwood & Mitnitski, 2007). .

The scale developed to reflect this conceptualisation of frailty, the original Accumulation of Deficits Model, uses a total of 70 physical and cognitive impairments, to assess frailty

severity (Rockwood *et al.,* 2005). Unlike the Frailty Phenotype, the Accumulation of Deficits adopted a scale scoring system. In principle, scores range from 0 to 1, with higher scores indicating greater frailty, but scores above 0.7 are rarely seen as they indicate a high risk of mortality within the following 6-months (Shi *et al.,* 2013). The frailty score is determined by dividing the number of impairments observed by the number of impairments assessed. For example, given a person with 10 identified impairments out of a total of 50 assessed, the frailty score would be 10/50 or 0.2.

The use of a scale scoring system, as opposed to the categorisation system adopted within the Frailty Phenotype, offers a more nuanced assessment of frailty. That is, a score able to properly represent meaningful change is produced as opposed to the categorical product. Rockwood, Andrew and Mitniski (2007) did, however, accept the benefits of categorising frailty for diagnostic purposes, and subsequently developed score ranges for frailty categorisation, with scores between 0 and 0.080 categorised as 'not frail/resilient', 0.081 to 0.250 as 'pre-frail', and 0.251 to 1 as 'frail'.

The main strength of the Accumulation of Deficits is the flexible design of the model that allows for the addition or removal of variables without compromising the reliability and validity of the tool as long as the variables included are related to frailty, increase in prevalence with age (but are not nearly universal i.e. ‘saturated’ in older age, for example, wearing reading glasses), and are present in at least 1% of the population (Moorhouse & Rockwood, 2012).

However, assessment with the Accumulation of Deficits is a time-consuming process that limits its practical applicability. In addition, and like the Frailty Phenotype, the Accumulation of Deficits focuses primarily on physiological markers of frailty and diagnoses of chronic illness with some items of cognitive ability included and therefore still only provides a

reductionist analysis of frailty. Furthermore, the Accumulation of Deficits approach is a binary assessment of the presence of an illness, and therefore fails to account for the severity of an illness.

A comparison of the Frailty Phenotype and Accumulation of Deficits Frailty Index was conducted based on the consistency between the two models in assessing frailty severity, as well as their predictive capabilities by Rockwood, Andrew and Mitnitski (2007). In terms of overlap, a moderate correlation between the two indices in terms of categorising individuals as robust, pre-frail, and frail was discovered. However, a translation issue was noted in that individuals considered robust under the phenotypic approach were, in many cases, categorised as frail under the deficits approach, but as frailty progressed the agreement of categorisation between the two models increased i.e. individuals who were categorised as frail in one model were also under the other. In terms of predicting outcomes, Rockwood, Andrew and Mitnitski (2007) argued that the scale scoring system implemented within the Accumulation of Deficits is the more capable method as risk of institutionalization and mortality continued to increase beyond the .25 score that would indicate a 'frail' state. These findings were supported by Li *et al* (2015) who concluded that the deficits model predicted the risk of falls, fractures, and mortality more precisely than the phenotypic approach.

These findings indicate that the flexibility of the Accumulation of Deficits and its scalar measurement of frailty offer several advantages over the categorical and limited scope of the Frailty Phenotype approach, yet both are reductionist approaches that focus on physiological illness and capability evaluation. As this thesis aims to examine the impact of psychological resilience on frailty, neither of these indices is suitable for this purpose.

Lally and Crome (2007) postulated that the focus on physiological markers is primarily due to their tangible nature, in that they can be objectively identified, and subsequently treated.

However, whilst tangibility is useful, it should not be used as a parameter to assess the importance or effect of a marker. Furthermore, objective analysis is not always possible or viable. For example, assessing an individual's capacity for everyday functioning, which is a key characteristic in evaluating frailty progression (Hamerman, 1999), can only be completed through self-assessment. Furthermore, to focus on objective analysis undervalues the benefits of using self-assessment in frailty assessment. This point is highlighted by Idler and Benyamini (1997) who reported that self-rated health uniquely contributes to predicting mortality, even when analysis are completed with covariates conducting objective health assessment. According to Miilunpalo, Pekka, Oja, Pasamen, and Urponen (1997) this is because self-reported health and objective health assessments analyse different facets of health, with self-reported health analysing biological, psychological, and social dimensions, whereas objective assessment considers only the medical component of health. Fried *et al* (2001) recognised the importance of self-assessment, which is reflected in the Frailty Phenotype as one of the five components assessed in the tool being self-rated health.

These findings highlight the reductionist approach adopted in frailty assessment, and if we are to fully understand the role of a multidimensional resilience in older adults, a similar holistic approach is required in frailty assessment. Despite the limitations outlined, the flexible design of the accumulation of deficits approach to frailty assessment makes it an ideal platform for developing a holistic frailty tool.

1.3. Towards a Holistic Frailty Assessment

A holistic approach to frailty would require a greater recognition of psychological, social, and environmental factors (Clarke & Nieuwenhuijsen, 2009; Ekwall, Sivberg & Hallberg, 2004; Fillit & Butler, 2009; Liu & Guo, 2007), and whilst there is a growing consensus for adopting

a holistic approach, this has yet to be realised in practice and there is little indication of it happening soon (Escourrou *et al.,* 2017). For example, a frailty conference held in 2012 with the aim of improving the operational definition of frailty focused solely on physical frailty traits (Morley *et al.,* 2013). Perhaps the lack of progress seen is due to inconsistencies in the definition and key markers of each dimension of frailty (Lally & Crome, 2007) but this should not deter us from taking the necessary steps to overcome these barriers and develop our understanding and assessment of frailty.

Some progress in this area has been made and several indices have been developed in an attempt to adopt a more holistic approach to frailty, such as the Groningen Frailty Indicator (Peters, Boter, Buskens & Slaets, 2012), and the Tilburg Frailty Indicator (Gobbens, van Assen, Luijkx, Wijnen-Sponselee & Schols, 2010), both of which assess physical cognitive, social, and psychological frailty markers. However, the Groningen Frailty Index failed to meet Rockwood's (2005) validation criteria i.e. frailty is more prevalent in women than men, increases with age, and the model must predict risk of hospitalisation, institutionalisation, and mortality (Theou, Brothers, Mitnitski & Rockwood, 2013; Turusheva *et al.,* 2016). The Tilburg Frailty Indicator, however, has been validated and possesses good psychometric properties (Gobbens *et al.,* 2010; Gobbens & van Assen, 2014), and predictive capabilities to adverse outcomes such as falls and death over a 12-year period (Gobbens, Schols, & van Assen, 2017). However, the level of validation is not comparable to the Frailty Phenotype (Fried *et al.,* 2001) or the Accumulation of Deficits tool (Rockwood *et al.,* 2005) and, according to Dent, Kowal, and Hoogendijk (2016) requires further substantial validation. Similar conclusions were made in Dent *et al's* (2016) review in relation to three more multidimensional indices: the Gerontopole Frailty Screening Tool (Vellas *et al.,* 2013), the Kihon Check-list (Satake *et al.,* 2016), and the Multidimensional Prognostic Index (Pilotto *et al.,* 2008). It is plausible that Dent *et al's* conclusions, which reflect favourably on indices

that primarily assess physical markers, are based on Rockwood's (2005) validation criteria, which are biased towards indices that focus on physical frailty assessment. Indeed, a closer examination of some of the frailty indices that possess a substantial, or exclusive, physical frailty component i.e. the Frailty Phenotype (Fried *et al.,* 2001), Accumulation of Deficits (Rockwood *et al.*, 2005), and the electronic Frailty Index (Clegg *et al.*, 2016), all have passed more robust levels of validation when compared to holistic frailty tools (Dent, Kowal & Hoogendijk, 2016). Therefore to provide a fairer assessment of the non-physical dimensions of frailty, additional outcomes associated with these dimensions of frailty should be incorporated into assessment, such as the ability to predict quality of life (Kojima *et al.,* 2016).

These conclusions not only highlight the difficulties associated with developing a holistic frailty tool that meets Rockwood's (2005) rigorous validation criteria, but also emphasise the difficulty of identifying the key markers of the psychological, social, and environmental dimensions of frailty. An alternate possibility is that issues validating the Groningen frailty index and Tilburg Frailty Indicator are because they use a different approach to determine frailty severity than either the Frailty Phenotype of Accumulation of Deficit tools. For instance, both models operate on a total score basis, the Groningen index requires a score of four or more for severe frailty, and the Tilburg Frailty Indicator 5 or more (both models have a maximum score of 15). Yet the items assessed in both models are partially ambiguous and open to interpretation. For example, in the Groningen Index cognition is evaluated using a single-item assessment. This not only raises questions to the capacity for cognition to be sufficiently assessed using a single item, but the item itself *'does the patient have any complaints on his/her memory (or diagnosed with dementia?'* can be interpreted in multiple ways. In one instance, the complaints about memory may indicate deterioration in cognition. Alternately, the lack of complaints (which would indicate good cognitive health) may be

because deterioration is extensive enough that the individual is not aware of their cognitive deterioration, but not considered severe enough to diagnose dementia. Similar issues of ambiguity are present in the Tilburg Frailty Indicator. This is not to question to viability of self-assessment of cognition as a whole. Indeed self-rated cognitive is strongly associated with cognitive deterioration (Amarilglio, Townsend, Grodstein, Sperking, & Rentz, 2011) and Alzheimer's disease (Correa, Graves, & Costa, 1996). Furthermore, self-reported measures (such as the Self-Report Measure of Cognitive Abilities; Freund, & Kasten, 2012) can be as effective as objective assessment (Herreen, & Zajac, 2017). Yet the method in which self-rated cognitive health is considered in the indices discussed does possess several significant limitations.

In the pursuit of a holistic tool, an alternate and more practical method would be to amend an existing frailty index in a step-by-step process of gradual change and this is the approach that will be taken within this thesis, and the one that is currently underway with the development of the Frailty Index (Holland *et al.,* 2015) which has already incorporated multiple psychological and functional markers into frailty assessment. Indeed this will be the focus of Chapter Two. However, before the proposed process of gradual development can be implemented, the key environmental and psychosocial markers must first be identified.

1.4. The Environment and Frailty

The role of the environment in frailty progression is ambiguous (Humpel, Owen & Leslie, 2002), and although it has been acknowledged that the environment possesses the capacity to both inhibit and stimulate frailty progression, there has been a reluctance towards its incorporation into frailty theory. This is highlighted by Markle-Reid and Browne (2003) who discovered that from five conceptualisations of frailty, only one (Raphael *et al.,* 1995)

incorporated environmental factors into the conceptualisation, with the other four viewing the environment as an important, but separate, construct (Buchner & Wagner, 1992; Bortz, 1993; Campbell & Buchner, 1997; Fried, 1994; Kaufman, 1994; Rockwood, Fox, Stolee, Robertson & Beattle, 1994; Walston & Fried, 1999).

Perhaps the problem here is a difficulty in conceptualising how the impact of the environment, seen as a fixed quantity for individuals living within the same community, changes as frailty progresses? And how can this change be represented in a frailty scale?

It is reasonable to conclude that such an approach is not feasible as we are unable to quantify this change, and incorporate it into a frailty scale, by assessing environmental resources only. Therefore it is argued that a shift in focus is needed, from assessing the environmental resources in the community towards evaluating how well the environmental resources available to the individual meet the needs of that individual.

Raphael *et al* (1995) have argued for exactly such an approach, defining their environmental index of frailty as the way in which the environment impacts on the individual's daily living. In the same spirit, this thesis will investigate individuals' perception of their environments and their beliefs about how well it meets their capabilities and fulfil their needs. To do this, however, an encompassing assessment of the environment that is representative of the needs of older adults, is required which, according to Plouffe, Kalache, and Voelcker (2016), should be based on the World Health Organization's (2007) definition of an Age-Friendly Environment.

1.4.1. Age-Friendly Environments

According to the World Health Organization (2007) the role of the environment in older adulthood is to facilitate and maintain independence and improve quality of life by enabling

the fulfilment of physical, cognitive, social, and spiritual needs and, the more of these needs that are fulfilled, the more age-friendly the environment is. The World Health Organization (2007) identified eight key dimensions to reflect the needs of older adults: housing, social participation, respect and social inclusion, civic partnership and employment, communication and information, community support and health services, outdoor spaces and buildings, and transportation, with each of these dimensions uniquely representing a key factor in maintaining independence in older adulthood. To determine the specific attributes of each component, the WHO implemented the age-friendly cities programme (World Health Organization, 2007). This initiative enlisted a total of 1,485 participants (consisting of people aged 60+, caregivers, and public service providers) from 33 cities across the world to take part in focus group research discussing each dimension. From these meetings, together with input from the active ageing framework (World Health Organization, 2002), and previous research (Kihl, Brennan, Gabhawala, List & Mittal, 2005), the characteristics of each dimensions were identified, which subsequently led to the development of the age-friendly environment checklist (World Health Organization, 2007), which is widely accepted as the gold standard of assessment of community age-friendliness (Buffel, Phillipson & Scharf, 2012).

Although the age friendly environment checklist offers the encompassing assessment of the environment, it was designed as a method for helping communities identify gaps within their local areas and set priorities for action, and is oriented towards community-level assessment. For this reason, the age-friendly environment checklist, in its current format, cannot be used in conjunction with current frailty assessment measures.

There are other environment assessment tools available, such as the Older Person's External Residential Assessment Tool (Burholt, Roberts & Musselwhite, 2016), the Neighbourhood Environment Walkability Scale (Saelens, Sallis, Black & Chen, 2003), and the Evaluation of

the Older People's Living Environments tool (Lewis *et al.*, 2010), but these tools either assess the environment on a community level (Burholt *et al.*, 2016; Lewis *et al.*, 2010), or only focus on a single aspect of the environment (Saelens *et al.*, 2003). The closest measure to fulfilling the criteria for an environment tool is the Age-Friendly Survey (Menec & Norwicki, 2014), which assesses seven of the eight age-friendly environment dimensions. However, this is a 54-item scale and therefore is a time consuming process, so to utilise it in conjunction with a frailty assessment would further increase the already extensive time constraints in assessing frailty. In addition, the scale uses a binary coding system, and therefore cannot be used to assess for change in perceptions of the environment as frailty progresses. Therefore, to address this issue, the Age-Friendly Environment Assessment Tool (Garner, & Holland, 2019) was developed. This is a 10-item scale that is designed to assess the age-friendliness of the environment from the individual's perspective. The development of this scale provided a pathway by which the environment can be assessed in conjunction with frailty.

1.5. Psychological Frailty

Of the unrepresented (in frailty assessment) dimensions of frailty, psychosocial frailty is considered the next dimension of frailty that should be identified and incorporated into assessment. Rodriguez-Manas *et al* (2013), using the Delphi method, found that over 80% of researchers who took part agreed that psychosocial markers should be incorporated into frailty assessment. However, the best way to identify which psychosocial markers need to be incorporated into such a frailty assessment instrument remains unknown. Andrew, Mitnitski, and Rockwood (2008) argued that a quantifiable definition of psychosocial frailty is required as this will provide the foundation for developing inclusion criteria. To this end, multiple definitions have been developed including Andrew *et al's* (2008) definition of psychosocial frailty as a form of social vulnerability (comprised of factors attributed to social

circumstances such as social support, social engagement, sense of control, and socio-economic status), whereas Escourrou *et al's* (2017) definition focused on social isolation as the key assessment criteria.

Despite these efforts, a universally accepted definition of psychosocial frailty and its constituent markers remains elusive. This has resulted in inconsistent conclusions regarding the prognostic and diagnostic capabilities attributed to different definitions of psychosocial frailty (Lally & Crome, 2007). For example, using Fried's Frailty Phenotype, Dent and Hoogendijk (2014) concluded that frail hospitalised participants with low psychosocial resources (assessed as a combination of well-being, sense of control, social activities, neighbourhood satisfaction, social relationships, anxiety, and depression) were at greater risk of mortality, requiring greater care on discharge from hospital, and were more likely to be re-hospitalised over a 12-month period than frail individuals with high psychosocial resources. Rockwood, Mitnitski, Song, Steen, and Skoog (2006) concluded that psychosocial factors were a greater predictor of autonomy, hospitalisation, and mortality than chronological age yet Hoogendijk *et al* (2014) did not discover any significant prognostic capabilities of psychosocial factors (assessed as a combination of sense of control, instrumental support, and emotional support) in relation to improving the predictive capabilities of frailty (assessed using Fried's (2001) Frailty Phenotype) in predicting future risk of mortality or functional decline.

These findings show the problems resulting from the failure to develop a definition of psychosocial frailty and highlight the usefulness of 'tangibility' suggested by Lally and Crome (2007). Physiological markers of frailty are 'tangible' in that they can be identified through a process of observation, whereas non-physical markers can be observed only indirectly making them less tangible and much more difficult to identify. For this reason, identifying 'non-tangible', psycho-social markers require a different theoretical approach to

that used for ‘tangible’ markers. One such approach would be to incorporate single psychosocial markers into frailty assessments, such as loneliness for which there is unambiguous and consistent evidence of their importance (Gale, Westbury & Cooper, 2018; Yanguas, Pinazo-Henandis & Tarazona-Santabalbina, 2018), one at a time, and utilise this step-by-step process to develop a holistic frailty assessment.

1.5.1. Loneliness, a Key Psychosocial Frailty Marker

Loneliness, defined as a perceived lack of social and/or emotional support (Young, 1982), is one of the few psychosocial variables that has already been incorporated into frailty assessment (De Witte *et al.,* 2013; Gobbens *et al.,* 2010) and there is unambiguous evidence regarding the negative effect of loneliness on health. For example, Shankar, McMunn, Banks, and Steptoe (2011) discovered an association between loneliness and depression, functional decline, and mortality; Chen and Feeley (2013) and Kojima, Iliffe, Jivraj and Walters (2016) discovered an association between loneliness and psychological well-being and quality of life; Gale, Westbury, and Cooper (2018) postulate that loneliness reduces psychological reserves and capacity to manage frailty progression; and Luo *et al* (2012) discovered loneliness is associated with an increased risk of mortality.

The interaction between loneliness and frailty has been examined from a number of different of perspectives. From a genetic perspective, Herrera-Badilla, Navarrete-Reyes, Amieva, and Avila-Funes (2015) postulated that frailty and loneliness share a phenotype due to the increased negative biological reaction to acute stress in lonely individuals compared to individuals who are not lonely. That is, lonely individuals react more negatively towards stressors than non-lonely individuals. From a physiological perspective, Sorkin, Rook, and Lu (2002) argued that loneliness increases risk of cardiovascular disease due to a heightened

negative response towards stressors, which is considered a key factor in frailty progression from a social perspective, there is consistent evidence suggesting that loneliness decreases physical activity and cognitive stimulation (Boss, Kang & Branson, 2015; Gale *et al.*, 2018; Shankar, McMunn, Banks & Steptoe, 2011).

These findings highlight the negative effects of loneliness and consistently display the interrelatedness between loneliness and frailty across multiple systems (Herrera-Badilla *et al.*, 2015), which suggests that loneliness is a key psychosocial marker of frailty, and provides ample theoretical justification for its inclusion in frailty assessment.

With the identification of potential key psychosocial and environmental frailty marker(s), their incorporation into the Frailty Index (Holland *et al.*, 2015) would provide a significant step towards the development of a holistic frailty tool, and one that is suitable to fully assess the relationship between resilience and frailty. Therefore, Chapter Two will review consider these candidate markers and if they warrant inclusion into Holland's (2015) Frailty Index.

1.6. The Frailty Index

The Frailty Index (Holland *et al.*, 2015), a 50-item frailty scale, operates under the operationalisation of frailty as an accumulation of deficits (Rockwood & Mitnitski, 2007). The items used in the Frailty Index derive from items used in the Accumulation of Deficits model (Rockwood *et al.*, 2005), and the index developed from the English Longitudinal Study of Ageing (Nazroo & Marshall, 2013). However, unlike many other indices, the Frailty Index includes a large psychological component in assessment, with 17 of the 50 markers assessed being psychological markers (the remaining 33 are physical markers).

Holland *et al* (2015) argued the benefits of adopting a multidimensional approach extended beyond a more representative evaluation of frailty progression, citing an ability of the Frailty

Index 50-item to assess frailty as a whole and determine frailty severity for separate dimensions. That is, the Frailty Index produces an overall frailty score, and scores for physical and psychological frailty only. This not only provides a greater accuracy in determining specific dimensions of frailty that require greater attention, but also helps determine the urgency with which an individual may need aid. That is, an individual who is both physically and psychologically frail will struggle with everyday functioning more than an individual who is only physically frail. This notion is supported by Collard *et al* (2012) who argued that the distinguishing of frailty dimensions provides a more accurate examination of the pathophysiological processes of frailty.

Holland *et al* (2015) also demonstrated that the Frailty Index possesses the ability to predict the need for formal care and the amount of care an individual needs based on their frailty severity. This result is especially important as previously, the prognostic capabilities of frailty assessments have typically been attributed to near end-of-life factors such as hospitalisation, institutionalisation, and mortality (Fried *et al.,* 2001; Rockwood & Mitnitski, 2007), none of which offer much scope for intervention. Holland et al.'s (2015) finding also offers the hope that other early risk factors, such as having a fall (Clegg *et al.,* 2013), can also be predictive. These potential predictive factors have the advantage over near end-of-life factors that they are relatively early stage and can potentially be managed (Rodakowski *et al.,* 2018).

Despite its potential, Holland *et al's* (2015) Frailty Index requires further development before it can be used and there remains the need to incorporate psychosocial and environmental markers into the tool. For instance, the omission of a physical activity marker was observed, despite it being one of the five key markers used in the Frailty Phenotype (Fried *et al.,* 2001), as well as its use in other indices (Ferrucci *et al.,* 2004; Gobbens & van Assen, 2012; Rockwood & Mitnitski, 2007; Speechley & Tinetti, 1991). The omission of polypharmacy (taking multiple prescribed medications) is also queried for two reasons: (1) polypharmacy is

associated with an increased risk of functional decline, having a fall, cognitive impairment, delirium, and dementia (Fox *et al.,* 2011; Landi *et al.,* 2014; Lowry, Woodman, Soiza & Mangoni, 2011; Morley, 2011); and (2) it is assessed in two validated scales: the electronic Frailty Index (Clegg *et al.,* 2016), and the Edmonton Frail Scale (Rolfson, Majumdar, Tsuyuki, Tahir, & Rockwood, 2006). Despite these limitations, as the Frailty Index utilises the accumulation of deficits approach, changes can incorporated into the index with little effect on the overall model.

Yet developing a frailty index is not merely a case of replicating specific aspects of other indices, and if we are to develop research, we must also be willing to go beyond this approach and attempt to incorporate previously untested items into assessment. Therefore as part of the development process the previously unused comorbidity 'joint effect' will be incorporated into the Frailty Index too. A joint effect is the combining of specific illnesses that result in a significantly worse adverse effect than that anticipated based on the individual effect of the illnesses (Hu, Jousilahti & Tuomilehto, 2007; Köhler *et al.,* 2012). Based on the illnesses and impairments assessed in the Frailty Index, the most applicable joint effect to incorporate is that of Coronary Heart Disease and Diabetes, which has been shown to significantly impair cognition (Verhaeghen, Borchelt & Smith, 2003) and increase the risk of mortality over a 2-year period (Haffner, Lehto, Rönnemaa, Pyörälä & Laakso, 1998; Mayer *et al.,* 2018). By identifying and incorporating joint effects into assessment a more representative scoring system of severe adverse effects would be present. As it is, using an accumulation of deficits approach, the Frailty Index operates under the assumption of equality of markers whereby high blood pressure, a condition that may have minimal impact on an individuals' daily life, makes the same contribution to frailty as significant illnesses such as cancer or having a stroke, which surely undervalues the effect of these severe illnesses. This point is reinforced as weighting the severe illnesses in deficit accumulation models has been shown to increase

predictive capabilities in relation to Alzheimer's disease, dementia, and death (Barnes *et al.*, 2009; Barnes & Lee, 2011; Song *et al.*, 2004), however the cost of this is a significant reduction to usability (Song, Mitnitski & Rockwood, 2014). Perhaps a better approach is to provide a new marker into the model, the joint effect, to provide a balance between providing a greater representation of more significant impairments and limiting generalisability.

Making these adjustments to the Frailty Index would require a re-validation of the model. However, as previously discussed, solely using Rockwood's (2005) validation criteria (a frailty index should be able to predict hospitalisation and mortality, frailty should be more prevalent in women than men, and increase with age), which favour physiologically-oriented frailty indices, may underrepresent the validity of the model. Furthermore, these criteria have also been shown to be inconsistent when assessed against the Accumulation of Deficits model. For example Kulminski *et al* (2011) and Turusheva *et al* (2016) did not discover any gender difference in terms of frailty severity and rate of progression. It is possible that this contradiction is due to the varying levels of resilience that help maintain functioning irrespective of age (Windle, 2012).

Therefore a broader method of validation is considered, using a combined approach of Rockwood's (2005) validation criteria and standard analytical validation techniques to assess reliability and validity. In addition, it is argued that the quality of a frailty index is determined by its predictive capabilities (Rockwood *et al.*, 2005), and therefore prognostic capabilities should also be considered in determining the validity of the tool. If the reliability and validity of the revised version of Holland *et al's* (2015) frailty index is confirmed (which will be determined in Chapter Two), it will provide the most viable option available for developing a frailty tool towards a holistic index, and therefore providing the optimal index to assess the relationship between resilience and frailty.

1.7. Resilience

Resilience is a dynamic and lifelong course that acts as a response mechanism towards a stressor (such as bereavement, severe illnesses, and/or a debilitating injury) with the goal of maintaining current homeostatic balance or, when necessary, to change and adapt (Fletcher & Sarkar, 2012; Whitson *et al.,* 2016) and is characterised by the utilisation of coping strategies that allow for functioning beyond what would be expected based on the stressor being experienced (Windle, 2011).

In older adults different forms of resilience are oriented towards specific purposes. According to Whitson *et al* (2016) physiological resilience focuses on the maintenance and/or recovery of function after physical and/or medical issues, whereas psychological resilience is a response mechanism to adversity, trauma, and/or significant stressors. Despite this, resilience in older adults is considered primarily from a physiological perspective. It is plausible that this is due to pathways for maintaining health and longevity, which is attributed to physical resilience, in older adults being the focus of research. This sentiment is shared by older adults who, when interviewed, cited health and longevity as the most vital component of quality of life (Levasseur, Tribble, & Desrosiers, 2009). This, however, means that the unique contribution of psychological resilience in the context of frailty is relatively unknown. Specifically, the effectiveness of coping strategies utilised and the benefits of maintaining high psychological resilience in old age.

These strategies can take many forms, but strategies associated with high resilience are strategies that either attempt to directly tackle the stressor i.e. positive adaptive coping, or reduce the negative impact of the stressor through emotional support i.e. emotional coping (Windle, 2011). The processes associated with both of these strategies vary depending on the stressor. For instance, social support is considered an essential coping strategy when overcoming bereavement (Logan, Thornton, Kane & Breen, 2018).

Yet, response mechanisms are rarely unidimensional in nature as stressors, especially in older adults, are more complex. For example, after suffering a fall older adults frequently cite a loss of physical functioning and confidence (Young & Williams, 2015). To overcome these issues both an increase in exercise (physical adaptation) and social support (emotional coping) is required. However, not all coping strategies are positive, and in many cases where an individual lacks the resources to overcome the stressor, the stressor is sometimes ignored (avoidant coping) or responses to a problem are ineffective and result in maladaptive outcomes and can result in further deterioration (maladaptive coping strategies). These forms of coping are negatively associated with resilience (Yi-Frazier *et al.,* 2009). Therefore, it is important to understand the stressor and the role of resilience within this context, identify a suitable method for overcoming the stressor, and provide the resources necessary for the coping strategies to be effectively implemented. This will be the focus of Chapter Three.

1.7.1. Resilience and Frailty

According to Rockwood and Mitnitski (2015), resilience is viewed as the polar opposite of frailty i.e. to be resilient is to not be frail, and vice versa. It is possible this conceptualization is strongly influenced by Baltes' Selection, Optimization, and Compensation theory (Baltes, & Carstensen, 2003; Heckhausen, & Schulz, 1993). This framework, which significantly overlaps with the coping mechanisms of resilience (dos Santos *et al.,* 2018), focuses on an individual's ability to self-reflect and adapt to maximise gains and minimise loss of resources as the individual ages, and is therefore strongly associated with healthy ageing (Baltes, & Baltes, 1990). With regards to the functional components of healthy ageing and frailty, it could be argued that these two definitions (with healthy ageing focusing on the maintenance of functioning and frailty the loss of functioning) are polar opposites, and therefore by being strongly associated with healthy ageing, resilience is conceptualised as the opposite of frailty.

However, this conceptualization contradicts and therefore challenges our understanding of frailty. For instance, greater frailty is associated with increased risk of death (Fried *et al.*, 2001; Rockwood *et al.*, 2005), and as frailty is more prevalent in women than men, it would therefore be expected that the life expectancy of women would be lower than men. Yet according to Collard *et al* (2012), when women and men live with similar frailty severity, women have a longer life expectancy. In addition, Shi *et al* (2001) concluded that women possess a greater frailty threshold (of 0.7 under the accumulation of deficits approach) before death when compared to men. One possibility for this is that more severe and life threatening health conditions, such as Cardiovascular Disease, are more prevalent in men than women (Hu *et al.*, 2004). Alternately, it is plausible that this difference, in part, can be attributed to an inherent resilience in women, or that resilience (if considered a component of frailty) is not considered in frailty assessment.

Resilience is also contextualised as a physiological construct in relation to frailty (Herrman *et al.*, 2011), although this may be a reflection of the focus on defining frailty through physiological means and the resistance towards integrating non-physical markers into frailty assessment (Lally & Crome, 2007). However, attempting to define the resilience-frailty relationship based on physiological foundations alone can result in developing an incomplete theory. For instance, physiologically speaking, the resilient-frailty relationship suggested by Rockwood and Mitnitski (2015) might be feasible. As frailty increases to near end-of-life severity, the ability to adapt behaviour to cope with frailty and maintain functioning, and therefore maintain resilience, is almost certain to be compromised. In this scenario extreme frailty would most probably imply the absence of resilience (Varadan, Walston & Bandeen-Roche, 2018). However, as age increases so too do the risks of adversity and stressors that are likely to result in some form of functional loss, and therefore to characterise resilience as the

absence of frailty would mean that very few people, if any, possess resilience in later life (Cosco *et al.,* 2017; Manton, Corder & Stallard, 1997).

In conceptualising resilience as the polar opposite of frailty we undermine the response mechanism component of resilience that is oriented towards regaining lost functioning (Christiansen, 2011; Herrman *et al.,* 2011). In doing so we also diminish our ability to provide an explanation of the individual differences observed in frailty i.e. how some individuals are able to react to, and recover from, illness and injury quicker and better than others, and how the 'tipping point' (the point of frailty progression when the system is unable to cope with frailty and drastic deterioration occurs) differs between older adults of the same age.

A theory more representative of resilience is that as defined by Cosco *et al* (2017), who stated that resilience is a response to frailty progression as well as a preventative measure, is influenced by physiological and psychological factors, and is characterised by greater independence, activity, and functioning beyond what would be expected based on the stressor(s) experienced. That is, frail individuals who are resilient will possess greater levels of functioning and well-being compared to frail individuals who are not resilient. This is not to say that the majority of frail older adults are resilient, indeed it is likely that many frail individuals lack resilience, but this is a matter of probability as opposed to inevitability. D'Avanzo *et al* (2017) and Holland, Garner and Gwyther (2018) supported and built on this notion, arguing that when an individual is unable to physiologically adapt to frailty, psychological coping strategies take a more prominent role in the maintenance of homeostasis, and referred to as being resilient despite the presence of frailty.

Yet little is known about the processes of psychological resilience in the context of frailty, how to define it, what the benefits of maintaining high psychological resilience despite the presence of frailty are, and how to foster it in frail older adults (Holland *et al.,* 2018).

One possibility for Holland *et al's* (2018) assertion is that Baltes' Selection, Optimization, and Compensation theory is not solely an underlying process of healthy ageing, but a continuous process as frailty severity increases. That frail but resilient individuals are better able to manage everyday issues than frail individuals who lack resilience. If Holland's (2018) assertions of psychological resilience are correct, then this process of Selection, Optimization, and Compensation would be performed predominantly through psychological adaptation. If combined with Selective, Optimization, and Compensation theory in relation to healthy ageing, then this would provide a full spectrum of how resilience operates, and in what forms, as age and frailty progress. In this scenario, it is recommended that psychological resilience be defined similarly to its physiological counterpart, as a process of response and adaptation. This conceptualisation may possess merit, but it remains theoretical. Indeed Holland *et al* (2019) cited the need for further research into the relationship between psychological resilience and frailty.

The issues surrounding current theory regarding the structure, definition, and purpose of resilience in the context of frailty have been highlighted. A potential pathway to build on this theory, to provide a conceptualisation more representative of resilience in the context of frailty, and to better understand how resilience operates as a response mechanism have also been considered. However, this theory requires confirmation, and if confirmed, a method for fostering psychological resilience must also be developed. Therefore, Chapter Three will address these issues.

1.7.2. Building Resilience in Older Adults

A pathway for building resilience in older adults requires identification. This is in part due to theory not yet being applied to practice, but also there being a focus towards building

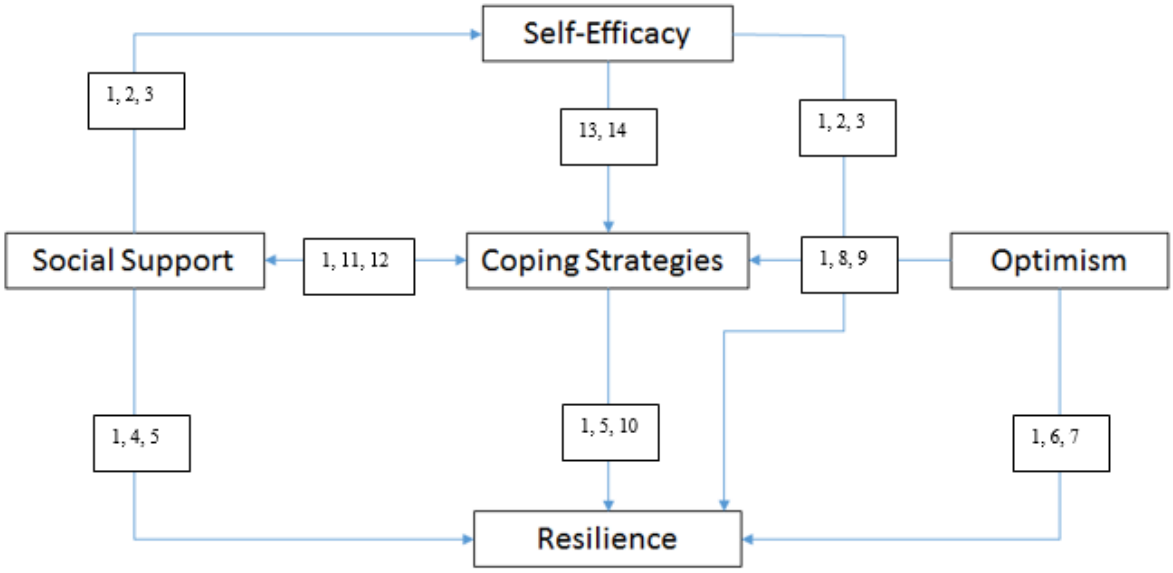
resilience in children (Windle, Salisbury & Cielsa, 2010). This means that the key factors of resilience in older adults remain unknown. This is especially important as the processes and key factors for building resilience are contextual and therefore key factors necessary for building resilience in one context can be less important within another (Ungar, 2008). For example emotional social support is a more important factor for building resilience in relation to life crises (Schaefer & Moo, 1998); whereas positive emotional regulation is more oriented towards managing and reducing the negative impact of stress (Folkman, & Moskowitz, 2000). In such absence of a definitive pathway for building resilience against a specific stressor, a method of building resilience would be to review similar stressors, where pathways for resilience and key traits are identified, and attempt to improve those markers in a manner more representative of the current stressor. For instance, following a natural disaster, resilience operates at a community level to cope irrespective of the disaster suffered (Ride & Bretherton, 2011). However, frailty is a unique phenomenon. Whereas traditional stressors are sudden, unexpected, and are directly identified as an issue to overcome (Fletcher, & Sarkar, 2012), frailty is a progressive development over time (Conroy, 2009), is seen by older adults as a natural part of ageing, and therefore lacks the unexpected impact sometimes necessary to facilitate change. Furthermore, current definitions of frailty do not conceptualise it as a stressor, but a predisposition to stressors (Conroy, 2009). This presents two purposes of resilience: (1) to reduce the predisposition of frail individuals to stressors; and (2) to reduce the impact of, and help overcome, stressors suffered as a result of frailty. Achieving these outcomes requires the identification of resilience markers in frailty, and a more nuanced approach to alter participants' perception of frailty as well as improve potential resilience building markers.

Despite these issues, there are key markers necessary to build resilience: social support, optimism, self-efficacy, and coping strategies. These four markers are consistently identified

as necessary components for building resilience in a variety of contexts across the lifespan, such as building resilience in children (Dumont & Provost, 1999; Hamill, 2003; Seligman, 2007), in university students (Coşkun, Garipağaoğlu, & Tosun, 2014; Souri & Hasanirad, 2011), in the workplace (Pipe *et al.,* 2011; Youssef & Luthans, 2007), family resilience (Benzies & Mychasiuk, 2009), and posttraumatic growth from health and trauma (Goodman & West-Olatunnji, 2008) etc. Across each context the role of each component remains relatively fixed. For instance, social support, as reviewed by Southwick *et al* (2016), is conceptualised on two levels, at the micro level there needs to be a sizeable and readily available support structure comprised of family and friends to provide comfort, advice and guidance to help overcome a stressor. At the meso (i.e. community, which is defined depending on the context of the stressor such as a school or workplace community) level, there is a greater emphasis towards a dynamic social network for integration within the community, and there must also be sufficient resources available to help deal with the stressor being experienced. Optimism provides greater belief that recovery from adversity is possible, and according to Scheier *et al* (1989) is strongly correlated with positive coping strategies and negatively associated with adverse and ineffective coping. Similar conclusions have been made about the relationship between self-efficacy and posttraumatic recovery (Benight, & Bandura, 2004; Ewart, 1992; Haaga, & Stewart, 1992; Strutton, & Lumpkin, 1992; Youssef, & Lutton, 2007). These components each contribute uniquely to implementing adaptive coping strategies when faced with a stressor, resulting in an increased likelihood that the desired outcome is achieved (Crego, Carrillo-Diaz, Armfield, & Romero, 2016; Taiwo, 2015; Tan-Kristanto & Kiropoulos, 2014).

It is plausible that these components have been identified as key resilience components due to their interconnectedness (which is presented below in Figure 1), which in turn creates a multi-level approach by which improving each item individually will have a unique and direct

beneficial effect on resilience as well as the other components which would in turn improve resilience further. For example, social support helps build self-efficacy as it facilitates positive reinforcement and encouragement from peers (Prati, & Pietratoni, 2009; Rutter, 1987; Taylor, & Reyes, 2012). Self-efficacy and optimism both produce an inner belief that the stressor can be overcome and therefore the individual is more likely to implement adaptive coping strategies (Major *et al.*, 1998; Nes, & Segerstrom, 2006; Prati, & Pietratoni, 2009). In addition to building resilience, these separate components all improve the resources available to the individual and facilitate the implementation of effective adaptive coping strategies.



[1]Prati & Pietratoni (2009); [2]Taylor, & Reyes (2012); [3]Rutter (1987); [4]Ozbay (2007); [5]Dumont, & Provost (1999); [6]Youssef, & Luthans (2007); [7]Strutton, & Lumpkin (1992); [8]Major et al (1998); [9]Nes, & Segerstrom (2006); [10]MacLeod et al (2016); [11]Kim et al (2011); [12]Thoits (1986); [13]Benight, & Bandura (2004); [14]Haaga, & Stewart (1992).

Figure 1: *The Interrelatedness between Key Resilience Markers.*

Further examination of the interconnectedness of these factors within multiple contexts has shown a trend whereby the secondary role of social support, optimism, and self-efficacy is to help improve the effectiveness of coping strategies implemented by individuals to overcome a stressor (as shown in Figure 1). Benzies and Mychasiuk's (2009) theorise as such, with

similar conceptualisations presented by Southwick, Litz, Charney, and Friedman (2011) in the contexts of mental health and deficit loss respectively.

This would suggest that we should consider coping strategies to be the primary factor in building resilience. Indeed Benzies and Mychasiuk (2009) stated that the factors outlined provide an ideal starting point for improving resilience. This is supported by Southwick *et al* (2011) who argue for the importance of coping strategies in building resilience in a series of contexts through the lifespan as opposed to specific cohorts. Whilst this is unsurprising given a primary component of resilience is the ability to adapt and overcome stressors, which is predominantly done through the use of positive adaptive coping strategies (Windle, 2011), it does offer a potential avenue for improving resilience in frail older adults. Therefore it would suggest that the focal point of improving resilience in the absence of a readily available method (i.e. building resilience in frail older adults) should be through improving the effectiveness of coping strategies implemented.

A viable pathway for building resilience in older adults has been identified, by increasing the likelihood that adaptive and/or emotional coping strategies are implemented in response to a stressor, and also improving the effectiveness of the strategies implemented. However, utilising these pathways in a resilience-building intervention tailored for older adults is still required. Therefore, Chapter Three will aim to address this, and Chapter Four evaluate the effectiveness of the intervention.

1.8. Thesis Aims and Overview

From the literature reviewed, several issues have been identified. There is an overutilization of physical markers in frailty assessment. This has led to validation procedures, which are based on indices using primarily physiological markers (Rockwood *et al.*, 2005), favouring

indices that adopt a similar approach. This bias also extends to interventions, with interventions using physically-oriented tasks considered the most effective in combating frailty. However, would these findings remain consistent if validation procedures were based on a holistic frailty tool? This highlights the need to adopt a holistic approach to frailty, but holistic tools developed have either failed to meet validation criteria, or the prognostic capabilities of indices are solely attributed to the physiological frailty dimension. These findings not only highlighted the difficulty in developing a holistic frailty tool, but also displayed the difficulty in accurately defining the psychosocial and environmental frailty dimension, determining what their key markers are, and what effects they have on frailty outcomes. Therefore a different pathway was contemplated; one of a gradual process of change to a current frailty index, with the Frailty Index (Holland *et al.*, 2015) considered the ideal frailty tool for this process due to it already possessing a large psychological input into assessment. However, it was also acknowledged that the Frailty Index required further development and validation, and that core psychosocial and environmental frailty markers are unambiguously determined before they can be incorporated into assessment to develop the holistic frailty tool. To this end, loneliness and age-friendly environments were reviewed as potential representative items of psychosocial and environmental frailty, yet confirmation of this is required.

The conceptualisation that resilience is a physiological construct and the polar opposite of frailty, which suggests that resilience is defined as the absence of frailty, fails to incorporate the psychological and response mechanism components of resilience into theory. Subsequently, the role of resilience in frail older adults is conceptualised in relation to healthy ageing as opposed to frailty. This is also reflected in the lack of a resilience-building intervention developed for frail older adults. Despite this, research has begun to expand on

resilience theory, and consider the effect of psychological resilience in frail older adults, yet this research is rare and requires further substantial analysis.

The aims of this current thesis therefore were:

1. To develop, validate, and improve the revised version of Holland *et al's* (2015) Frailty Index.
2. To determine if loneliness and perceptions of environmental age-friendliness should be incorporated into the Frailty Index and develop it towards a holistic frailty tool.
3. To analyse the effect of psychological resilience (defined as a process of coping and adaptation, Cosco *et al*., 2017) on frailty and frailty outcomes.
4. If justifiable, to develop and implement an intervention to improve the effectiveness of coping strategies implemented against a stressor, and subsequently build resilience.
5. To discuss findings, implications, limitations, and future research of the studies completed within this thesis.

Chapter 2 Aims

The first aim of Chapter 2 will be to further develop, validate, and improve the revised version of Holland *et al's* (2015) Frailty Index. This will be completed in Studies 1 and 3. Once the validation process is complete, this chapter will also compare the prognostic capabilities of the frailty index against previous versions to ensure no loss of reliability and validity was observed, and against other indices as the first part of the quality comparison assessment (Study 2). This chapter, in Study 3, will then consider the potential of incorporating assessments of loneliness and perceptions of environmental age-friendliness into the revised Frailty Index. If either of these variables is justifiably included into the tool,

the predictive capabilities of the holistic version of the frailty index will be compared to previous versions of the model and against other indices as a quality comparison assessment.

Chapter 3 Aims

The aim of Chapter 3 will be to determine if improving psychological resilience can have a direct effect frailty, or improve frailty outcomes either directly or by reducing the negative effect of frailty. This will be completed in Study 4. Secondly, if justified, this chapter will then (in Study 5) continue to develop a resilience-building intervention through a process of co-creation with stakeholders.

Chapter 4 Aims

The aim of Chapter 4, and the final study (Study 6) of this thesis, will implement the resilience-building intervention and analyse the effectiveness of the programme developed. This will be done using a mixed methods approach to determine the effectiveness of the intervention.

Chapter 5 Aims

Chapter 5 will provide a general discussion surrounding the principal findings of the thesis, the implications of the findings, how it links to theory, and provide direction for future research.

Chapter 2

The Frailty Index

2.1 Chapter Aims

Attempts to develop a holistic frailty tool that assesses physical, cognitive, psychological, social, and environmental frailty markers have failed to satisfy the necessary validation criteria and require further substantial validation (Dent *et al.,* 2016), and there is little evidence of any new instruments emerging (Escourrou *et al.,* 2017). It was therefore considered that an alternate pathway towards a holistic frailty tool was required (as discussed in Chapter 1), in which a current frailty tool be adapted through a process of gradual change by incorporating non-physical frailty markers into a frailty tool. The Frailty Index (Holland *et al.,* 2015) is the preferred frailty assessment instrument because it already includes a large psychological component and because its design makes it readily adaptable. Yet the tool requires further development. This will involve the removal of current markers and the potential additions of new ones. Following this the limitations of the tool will be considered and improvements be made to address these limitations. Favourable findings from these processes will confirm the suitability of this tool in the current thesis.

In the event the Frailty Index meets validation criteria and is deemed sufficient for the current thesis, the next stage would be to incorporate psychosocial and environmental frailty markers into assessment, yet there is significant ambiguity surrounding both frailty dimensions in relation to how they are defined and assessed. These issues were considered in Chapter One and it was theorised that the constructs loneliness and age-friendly environment from the older person's viewpoint are representative of psychosocial and environmental frailty respectively, and will be considered as the frailty markers to be incorporated into assessment. However it must first be confirmed that both markers will significantly improve the frailty index to justify their inclusion.

Chapter 2 will consist of three studies. Study 1 will refine Holland *et al's* (2015) Frailty Index through the removal, and potential addition, of markers. Following this, the revised tool will be re-validated against Rockwood's (2005) validation criteria and standard analytical procedures. The final stage of Study 1 will be to consider the limitations and pathways for improvement. Study 2 will then implement these changes to address the limitations of the model and re-validate the tool. The quality and capabilities of the revised tool will be compared to the previous version to ensure no prognostic capabilities were lost when the limitations were addressed, and against other indices to compare the capabilities of the revised tool against top frailty indices. The third and final study will then consider the potential incorporation of candidate items into the frailty index designed to assess loneliness and perceptions of environmental age-friendliness from the person's viewpoint. If justified and the new markers are added to the index, the final analysis will be to compare the holistic tool against previous versions

In summary, this chapter will be comprised of three studies:

1. Study 1 - Revise and refine Holland *et al's* (2015) Frailty Index
2. Study 2 - Address the limitations of the Frailty Index identified in Study 1.
3. Study 3 - Consider the markers loneliness and perceptions of environmental age-friendliness for inclusion into the revised Frailty Index. If included, evaluate for change in prognostic capabilities by their inclusion.

2.2. Study 1: Development and Validating the Frailty Index

2.3. Introduction

The Frailty Index 50-item (Holland *et al.,* 2015) was built under the conceptualisation the frailty is defined as an accumulation of deficits (Rockwood *et al.,* 2005), and utilises a large psychological contingent in assessment, with 17 of the 50 markers assessed psychological markers. Early indications have shown that the Frailty Index is able to significantly predict the risk of needing formal care (Holland *et al.,* 2015). This is especially important as typical prognostic capabilities are attributed to near end-of-life and therefore lack scope for intervention.

Despite the potential of Holland's Frailty Index, closer examination of the tool indicates that further developments are required. Specifically, the removal of the variable 'falls' as a predictor, and the potential inclusion of three candidate items: (1) exercise frequency, which is an assessment of physical activity; (2) polypharmacy, which reviews the number of prescribed medications an individual takes (four or more); and (3) the Coronary-Heart Disease-Diabetes joint effect, which accounts for the additional adverse health effect when both conditions are present. Implementing these alterations requires the re-validation of the tool.

Validation typically follows Rockwood's (2005) criteria, which states that the model should predict both death and hospitalisation, that frailty severity should increase with chronological age, and should be more prevalent in women than men. However, we question the applicability of this set of criteria as a viable validation pathway as Rockwood's criteria are based on an index designed for a medical environment, which focuses more on management of frailty as opposed to treatment. Alternately, Holland *et al's* (2015) Frailty Index is designed for the community population, in which improving health and functioning is a primary

objective (Holland *et al.,* 2017; 2019). Distinguishing between these two environments is important as findings by Kulminski *et al* (2011) and Turusheva *et al* (2016), who both used an accumulation of deficits frailty assessment on community populations, found contradictory evidence to Rockwood's validation criteria. Therefore we postulate considering a combined approach of Rockwood's validation criteria and standard analytical procedures. To further validate the Frailty Index additional analyses should be performed based on conclusions made regarding the predictive capabilities of other frailty indices. Specifically the ability to predict the need for formal care (Holland *et al.,* 2015), and falls (Clegg *et al.,* 2016).

2.4. Aims

1. Assess whether potential candidate variables (polypharmacy, exercise frequency, and Coronary Heart Disease & Diabetes joint effect) can be incorporated into the Frailty Index.
2. Assess the internal reliability and test-retest reliability of the Frailty Index.
3. Assess the convergent, construct, and prognostic validity of the Frailty Index.

2.5. Chapter Two Methods

2.5.1. Collaborative Research between ARCHA and the ExtraCare Charitable Trust

ExtraCare housing, run by the ExtraCare Charitable Trust, aims to meet the physical, cognitive, and social needs of older adults to sustain independence in their own accommodation (Netten, Darton, Baumker, & Callghan, 2011). This is done by providing on-site facilities such as a convenience store for day-to-day necessities, entertainment facilities such as woodwork and arts & crafts rooms, and professional health information through the 'well-being' advisor (a nurse) for health assessment and support. The health of residents in

ExtraCare villages also varies, from highly robust individuals who maintain an active lifestyle in and outside the village to individual who needs significant levels of care on a daily basis. On average, 30% of residents living in retirement villages receive care (although this is substantially higher in retirement schemes).

The collaborative research project between the Aston Research Centre for Healthy Ageing (ARCHA) and the ExtraCare Charitable Trust was completed over a 7-year period (Holland *et al.*, 2015; 2017; 2019). The purpose of this research was to evaluate the longitudinal benefits of living in an ExtraCare retirement village as opposed to the local community. This was done by evaluating the change in health (assessed using Holland *et al's* (2015) Frailty Index) and outcomes (such as considerations to physical health, psychological well-being, social well-being, and healthcare costs) over time and comparing the difference in change between ExtraCare residents and residents living in local communities (i.e. control participants).

There were a total of eight assessment periods in the longitudinal study, which were based on how long the ExtraCare participants lived in an ExtraCare retirement village for: 0 months (i.e. just moved in, referred to as Baseline; BL), 3 months (referred to as F1), 12 months (referred to as F2), 15/18 months (F3), 24 months (F4), 36 months (F5), 48 months (F6), and 60 months (F7). New participants recruited were allocated to a specific time period depending on how long they lived in the village for prior to their first assessment. For example, a new participant who lived in a village for 12 months prior to taking part in the study would be allocated to the 12 month point (F2), and all following assessment would proceed along the timeline from F2 onwards (i.e. there next assessment would be within either 3 months or 6 months in line with the F3 time point of 15/18 months). Participants recruited from the local community (acting as the control group) were matched against ExtraCare participants based on their age. For example, if the average age of ExtraCare participants at the F2 time point was 75, F3 76, and F4 77, a newly recruited community participant with the average age of 76

would have their first assessment allocated to the F3 time period, and all subsequent assessments follow the time period from therein (this means their second assessment would within 6 to 9 months as the F4 period is a 24 month mark). Over the longitudinal study (including the follow-up study), a total of 273 participants were recruited and a total of 862 assessments completed. Participant distribution across the eight time points is presented below in Table 1.

Table 1: *Total Assessments completed at each Time Point (months) in the Longitudinal Study.*

	BL (0)	**F1 (3)**	**F2 (12)**	**F3 (15/18)**	**F4 (24)**	**F5 (36)**	**F6 (48)**	**F7 (60)**
ExtraCare	162	149	137	126	55	46	29	16
Community	31	32	33	14	6	21	5	0
Total	193	181	170	140	61	67	34	16

On average, ExtraCare participants were frailer (average frailty score ranged from .185 to .230 across all assessment points compared to community participant frailty score range of .067 to .118) and suffered more falls than community participants. Average healthcare costs were also higher (computed based on the number of medical visits, prescribed medications, and care an individual received) in ExtraCare participants. There was, however, little difference in the number of co-morbidities participants lived with in either cohort, and this remained consistent over time (ExtraCare participants live with an average of 1.7 co-morbidities and community participants 1.4 co-morbidities, and at the 24 month time period ExtraCare participants lived with 2.49 co-morbidities and the community sample 2.51 co-morbidities). Across all health and well-being components assessed, ExtraCare participants possessed a greater level of variation compared to the community cohort, and is therefore the ideal cohort for validating the revised version of Holland *et al's* (2015) Frailty Index.

Holland *et al's* (2019) report concluded that over the first 24-months of living in an ExtraCare retirement village, an improvement in frailty, perceived health, autobiographical memory, and cognition is observed. However, at the 48-month, many of the improvements observed reverted to baseline levels. Despite the long-term outcomes, these findings do indicate that the ExtraCare environment does possess an interventional component to its functioning, as shown by the initial improvements made.

2.5.2. Longitudinal Study and the PhD Research

In the context of the longitudinal study, the goal of the PhD research was to continue data collection to facilitate the longitudinal analysis beyond the 24-month point of assessment. The data gathered in both the longitudinal study and the PhD was then used to perform research independent of the ExtraCare Charitable Trust, although the ExtraCare population remained the focal point of all research conducted.

2.6. Participants

A total of 75 participants were recruited from local communities in the West Midlands of the UK (56 participants) and ExtraCare retirement villages (19 participants) as part of the longitudinal study '*Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and the ExtraCare Charitable Trust - a follow-up*', which is a continuation and expansion from the study '*Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and the ExtraCare Charitable Trust*' (Holland *et al.*, 2015). From the participant recruitment outlined and the longitudinal study, a total of 351 participants (135 male, 214 female, and aged 57-96) were used in this study. The 351 participants completed a total of 1011 assessments, 118 of which were from the 75 participants recruited.

Of the 118 assessments that were completed, 5 were allocated to F1 (4 ExtraCare, 1 community), 4 to F2 (4 ExtraCare), 28 to F3 (22 ExtraCare, 6 community), 29 to F4 (5 ExtraCare, 24 community), 29 to F5 (5 ExtraCare, 24 community), 22 to F6 (15 ExtraCare, 7 community), and 8 to F7 (6 ExtraCare, 2 community). A combined breakdown of the full participant recruitment at each time point for ExtraCare and community participants for the longitudinal study and PhD recruitment is presented below in Table 2.

Table 2: *Participant Recruitment for the Longitudinal Study and PhD at each Time Point.*

	BL (0)	**F1 (3)**	**F2 (12)**	**F3 (15/18)**	**F4 (24)**	**F5 (36)**	**F6 (48)**	**F7 (60)**
ExtraCare	162	153	141	132	60	51	44	22
Community	31	33	33	36	30	45	12	2
Total	193	186	174	168	90	96	56	24

The majority of participants completed multiple assessments. All longitudinal analyses were completed over a 24-month period (this is due to participant retention reducing beyond the 24-month point). For cross-sectional analyses, the most complete data set for each participant was used for the analysis (as the longitudinal study progressed new measures were added into assessment, and therefore earlier assessments would possess missing data for these measures).

2.7. Ethics

All ethical procedures of the longitudinal study are aligned with BPS guidelines and the study received a favourable opinion from the Aston University Life and Health Sciences Committee.

Informed consent was gained by providing participants with an information sheet outlining their rights of withdrawal and anonymity as participants and what the study entails. Furthermore, prior to participation a judgement based on participants mental capacity to give informed consent was made. For participants living with dementia, capacity to give consent was considered under the Mental Capacity Act of 2007 and the 2 Stage Test of Capacity (Mental Health Act, 2007). Participants were also informed they could take a break at any point during the study.

Participants were given an ID number which would be referred to when being recorded as part of assessments to maintain anonymity. Furthermore, as part of the assessments included a 12-month medical review which included general observations such as blood pressure, cholesterol and blood glucose levels, participants were informed of any results that may indicate a health risk with a course of action recommended, e.g. contact a general practitioner or ExtraCare well-being advisor (a qualified nurse). As participants were fully informed about what the study entails prior to their participation, no debriefing was required.

Sensitive participant information in which participants could be identified was kept on a password protected computer, and the document containing the information was also password protected. Data were stored with ID numbers only, separately from the information that linked ID numbers with names and contact details. Furthermore, all raw data was kept in a locked cabinet. Participants were informed in the consent form that we had a duty of care so that if we identified a serious risk of harm - e.g. an illness or a crime, we had to inform an appropriate person.

2.8. Measures

2.8.1. General Health

A series of items are examined in this assessment such as perceived health (5-point likert scale ranging from excellent to poor) and relative health (3-point scale with the options 'getting better', 'same', and 'getting worse') compared to 12-months prior, grip strength (which was assessed using a grip strength machine), walking speed (based on a metres/second calculation from participants walking 7 metres), sit-to-stand speed (measured in seconds and assessed using a stopwatch), and feelings of exhaustion (4-point scale assessing how many days in the week the participant felt like everything they did was an effort).

2.8.2. Activities of Daily Living

The activities of daily living (ADL) is an assessment of basic activities that are important for independent home and community living. This includes factors such as personal hygiene, dressing, eating, maintaining continence, and transferring (Katz, 1983).

2.8.3. Instrumental Activities of Daily Living

The instrumental activities of daily living (IADL) are important components of independent living but not required on a daily basis. This includes factors such as communication skills, transportation, meal preparation, shopping, housework, and managing medication and personal finances (Lawton & Brody, 1969).

2.8.4. Hospital Anxiety and Depression Scale

The Hospital Anxiety and Depression Scale (HADS) is a self-assessment of anxiety and depressive symptomology. Scores range from 0 to 21 and higher scores are indicative of greater anxiety and depressive symptomology (Zigmund, & Snaith, 1983).

2.8.5. Control, Autonomy, Self-Realization, and Pleasure 12-item

The control, autonomy, self-realization, and pleasure 12-item (CASP12) is a measure of quality of life. Each component of the CASP12 is designed to measure a different aspect of quality of life. Scores range 12-48, with higher scores indicative of greater quality of life (Wiggins *et al.*, 2008).

2.8.6. Functional Limitations Profile

The functional limitations profile (FLP) is an assessment of how individuals perceive that their health impacts on their functions across a variety of domains: ambulation, mobility, household management, recreation and pastimes, social interaction, emotional behaviour, alertness, sleep and rest, communication and work (Pollard & Johnson, 2001). Participants are read a series of statements (each possesses a functional limitation score) and asked if that statements accurately described their everyday life. Statements are read until an accurate statement is found (or until all options have been exhausted, in which participants score 0 for that component of the FLP). After completing the FLP, scores are summed (ranging from 0 to 883), with a higher FLP score indicative of poorer functioning.

2.8.7. Addenbrooke Cognitive Examination-III

The Addenbrooke Cognitive Examination-III (ACE-III) is an assessment of cognitive capabilities. This examines five different aspects of cognition: attention, memory, fluency, language, and visuospatial functioning. Lower ACE-III scores are indicative of greater cognitive impairment (Noone, 2015).

2.8.8. Well-Being Assessment

The Well-Being Assessment (WBA) is a 12-month medical review that examines all medical-related issues. The WBA is responsible for three assessment components of Holland *et* al's (2015) Frailty Index: (1) the assessment of medical-related component (assessments of Blood Pressure, Coronary Heart Disease, Diabetes, Stroke, Lung Disease, Asthma, Arthritis, Osteoporosis, Cancer, Parkinson's, eyesight, self-reported hearing, hip fracture, joint replacement, Body Mass Index, psychiatric, and Dementia); (2) the amount of exercise an individual takes per week; and (3) the number of prescribed medications (for the candidate item 'polypharmacy') has. The WBA also asks questions related to outcomes of frailty, such as the number of falls and hospital visits in the 12-months prior to the assessment and if the individual receives any care, and if so, how many hours per week.

2.9. Procedure

After informed consent was gained, participants completed a series of assessment designed to determine their frailty severity and outcomes associated with frailty. This process was completed at set intervals (as discussed in the participants section and displayed in Table 1), with a maximum time period of 12-months between assessments, over a 4-year period.

2.10. Data Analysis

2.10.1. Content Analysis for Inclusion of Candidate Items

The raw score conversion of the variable polypharmacy into a 0-1 coding system was based on ExtraCare health assessment, in which participants who take four or more medications are considered at risk of adverse effects. Evidence supports that national guidelines of five sessions of 30 minutes per week (World Health Organization, 2010), and therefore this was used to develop a scoring system for exercise frequency (see Table 3 below). Finally, a binary coding system was implemented for the CHD & Diabetes comorbidity variable. The conversion of raw scores to 0-1 coding is displayed below in Table 3.

Table 3: *Conversion Scores for Candidate Items*

Exercise Frequency	Polypharmacy	CHD & Diabetes
0-1 days per week = 1	4+ medication = 1	Both Diagnosed: Yes = 1
2-3 days per week = 0.66	0-3 medications = 0	Both Diagnosed: No = 0
4 days per week = 0.33		
5-7 days per week = 0		

A Pearson correlation analysis will be performed to determine if the candidate variables (polypharmacy, exercise frequency, and Coronary Heart Disease & Diabetes joint effect) correlate with the frailty score derived from Holland's Frailty Index. This will confirm their suitability to be incorporated into the tool without compromising the reliability and validity of the model (Rockwood *et al.*, 2005). If the items are added to the model, the new 52-item will be used for subsequent validation analyses.

2.10.2. Internal Reliability

Internal reliability, the extent to which all items assess the same construct (which is reflected in the similarity of scores gained across the items within the tool), was determined by assessing the Cronbach's Alpha score of the Frailty Index. The ideal target range for this score, according to Pallant (2011), is a Cronbach's Alpha score within the range from 0.7 to 0.9 as this would be indicative of high internal reliability with a low risk of item redundancy (i.e. items that significantly overlap with other items to the extent their inclusion does not provide a unique contribution to the model and therefore should be removed).

2.10.3. Test-Retest Reliability

As frailty is progressive, changes over time should be expected but, over short periods of time these should be negligible and between-subject differences should be relatively stable, and if such an outcome was observed then test-retest reliability would be confirmed. To determine this, an intraclass correlation was performed. This form of correlation analysis was chosen as an intraclass correlation, under the condition of absolute agreement, compares the change in scores on an individual basis between two time periods. Little/no change in score (which is the optimal outcome of assessment) is represented by a high intraclass correlation score. In this analysis an intraclass correlation score of .800 or higher would be indicative of high test-retest reliability (Bartko, 1966).

2.10.4. Convergent Validity

To assess convergent validity (the extent to which the Frailty Index correlates with other frailty indices), a total of six frailty tools were re-created using data collected in the

longitudinal study and current thesis and a correlation analysis was performed between these indices. The frailty indices re-created are as follows:

1. **Frailty Phenotype:** The Frailty Phenotype (FP; see Appendix A) assesses five different frailty factors to determine severity: unintentional weight loss (4.5kg or more over a 12-month period), slow walking speed, weak grip strength, physical inactivity, and feelings of exhaustion. The presence of three or more of these factors is indicative of a frail state (Fried *et al.,* 2001).
2. **CSHA Frailty Index:** The Frailty Index derived from the Canadian Study of Healthy Ageing (CSHA Frailty Index; see Appendix B) is a 70 item too consisting of physical and cognitive items. This provides a score ranging from 0 to 1 and the closer the score is to 1 the more severe frailty is (Rockwood *et al.,* 2005). Rockwood and Mitnitski (2007) categorise scores above .250 as frail.
3. **Groningen Frailty Index:** The Groningen Frailty Index (GFI; see Appendix C) is a 15-item scale that assesses physical, cognitive, and psychosocial frailty components. Participants can score from 0-15 on this scale, with scores above 4 indicative of a severely frail state (Peters *et al.,* 2012).
4. **Tilburg Frailty Indicator:** The Tilburg Frailty Indicator (TFI; see Appendix D) is a 25-item scale (10 demographic items, 15 frailty component items) that assesses physical, psychological, and social frailty components (Gobbens *et al.,* 2010). Scores range from 0-15 and scores of five and above are indicative of a frail state.
5. **electronic Frailty Index:** The electronic Frailty Index (eFI; see Appendix E) is a 36-item scale (consisting entirely of medical condition assessments) specifically designed for use in a General Practice setting (Clegg *et al.,* 2016). Its main strength is that it can be automatically completed by extracting data from participant records.

6. **Edmonton Frail Scale:** The Edmonton Frail Scale (EFS; see Appendix F) is an 11-item scale that assesses physical, cognitive, and social frailty components (Rolfson *et al.,* 2006). Scores range from 0 to 17, with scores of 12 and above indicative of a severe frail state.

An exact re-creation of each frailty index was not possible based on the data available. Therefore minor amendments were made in relation to specific variables within each tool. These changes are described below in Table 4.

In addition to the changes outlined in Table 4, a multiple imputation[1] was performed due to large amounts of missing data for variables used in the Frailty Phenotype. Data was absent from 29.5% of participant scores about weight loss, 44.8% about feelings of exhaustion, 31.6% for physical activity, 30.6% regarding walking speed, and 24.1% for grip strength. This resulted in only 161/351 participants possessing full data sets.

[1]Multiple imputation is a process of estimating the 'true' value of missing data (Rezvan, Lee & Simpson, 2015). Available data is assessed for patterns and inferences are made as to what the most likely answer would be based on data that is available. However, Multiple Imputation is also contentious as it reduces participant behaviour to patterns, when behaviour is more complex and unpredictable.

Table 4: *A Table Displaying the Changes made to the CSHA, FP, GFI, TFI, eFI, and Edmonton Frailty Scale*

Scale	Variable Alteration	Justification
CSHA Frailty Index (70-items)	Removal of 10 variables to make the index a 60-item model.	These variables assess either individual or/and family history of illness. No such data was collected in the current study.
	Toilet and continence variables merged	Both are assessed as a single variable in the instrumental activities of daily living assessment.
electronic Frailty Index (36-items)	'Memory and Cognitive problems' replaced with ACE-III assessment.	No medical assessment of memory and cognitive problems was completed. The ACE III Memory assessment was used as an objective assessment instead.
Groningen Frailty Index (15-items)	Feelings of depression or anxiety	Yes/no variables changed. New variables used HADS scale used with 0-7 scoring 0 and 8+ scoring 1.
	Memory Issues changed to ACE III memory assessment	Subjective self-reported memory issues not assessed. ACE III memory variable utilised instead to determine memory issues (see eFI changes).
	Self-perception of health scale changed	0-10 scale changed to the 5-point perceived health assessment used, with 'very good' and 'excellent' responses scoring 0 and 'good', 'fair', and 'poor' scoring 1.
Tilburg Frailty Indicator (15-items)	Assessment of balance altered to having a fall	No direct assessment of balance was made; having a fall was instead used. This was due to falls likely attributed to poor balance.
	'Social component' of assessment removed	No data can be utilised as a proxy assessment of subjective social assessment. Therefore these 3 items were removed from assessment.
Edmonton Frailty Scale (9-items)	Nutritional assessment of clothes fitting changed to being underweight (<18% BMI)	Weight used as a proxy assessment for significant weight loss.
	Two functional independence variables, cognition, social support, and forgetting medication not assessed.	No data available to utilise as a proxy and therefore the 2 variables were removed. Scoring was amended to compensate for this. 0-2 = not frail, 3-4 = vulnerable, 5-6 = moderate frailty, and 9+ = severe frailty.
Frailty Phenotype (5-items)	Unintentional weight loss adjusted to being underweight (BMI<18)	Large portion of sample (24%) only completed a single assessment and therefore unintentional weight loss could not be determined.

2.10.5. Construct Validity

To assess the level of construct validity, the extent to which the model measures what it is supposed to measure, a t-test will be performed to determine if a significant gender difference in frailty scores is present. Furthermore, a correlation analysis will also be performed to determine if a significant positive relationship between frailty and chronological age, and frailty and the average duration of a hospital stay is present. In addition to this, a series of linear regressions will be performed to determine if the Frailty Index significantly predicts the amount of formal care an individual receives on a weekly basis (Holland *et al.*, 2015, 2019), quality of life (Gobbens & van Assen, 2014; Kojima *et al.*, 2016), and the number of falls an individual has suffered over a 12-month period (Clegg *et al.*, 2013). The confirmation of a significant gender difference, significant predictive capabilities in predicting quality of life, and the number of falls and hospital admissions over a 12-month period, and significant, positive frailty-age and frailty-average hospital stay relationships would be consistent with Rockwood (2005) and therefore indicate high construct validity.

2.10.6. Prognostic Validity

To assess the prognostic validity (sometimes referred to as predictive validity), the degree to which the model predicts the risk of adverse outcomes occurring, a series of Cox Regressions will be performed to determine if the Frailty Index significantly predicts the risk of needing formal care (Holland *et al.*, 2015; 2019), having a fall (Clegg *et al.*, 2013), being hospitalised (Fried *et al.*, 2001) and mortality over a 2-year period based on a baseline frailty score. Survival curves were also provided as a graphical display of the change in risk of the 'event' occurring as frailty progresses for each outcome.

2.10.7. Sensitivity and Specificity Assessment

A sensitivity and specificity assessment, the extent to which the Frailty Index correctly predicts an outcome either occurring or not occurring based on a baseline frailty score, will be assessed using Receiver Operating Curves (ROC) on the outcomes falls, hospitalisation, care requirements, and death.

Data were analysed using Statistical Package for Social Sciences (SPSS Version 23).

2.11. Results

2.11.1. Content Validity of the Candidate Items

There were significant correlations between frailty and CHD & Diabetes comorbidity joint effect (r = .209, p<.01), exercise frequency (r = -.431, p<.01), and polypharmacy (r = .379, p<.01) was discovered, indicating severe frailty is associated with a need for more medication, and living with both CHD and Diabetes. The significant correlations discovered fulfil the requirements of Rockwood and Mitnitski (2007) and therefore the next stage was to incorporate the variables to the Frailty Index.

With the inclusion of the three new variables, and the removal of the variable ‘falls’, the Frailty Index became a 52-item index (FI52) which was subsequently used for the validation procedure.

2.11.2. Descriptive Statistics

The number of participants, mean, standard deviation, median, interquartile range, and range of participants data for frailty scores and the variables quality of life, care requirements (total hourly care an individual receives on a weekly basis), number of hospital admissions (a

combined total of planned and unplanned hospital stays over the previous 12 months) and hospital stay (measured in days spent admitted to hospital). When discussing hospital stay, 21 participants were unable to provide accurate information regarding the length of their hospital stay(s), therefore no answer was provided.

As gender differences are important in determining the validity of a frailty scale (Rockwood *et al.,* 2005), descriptive statistics will provide a total score and separate scores for men and women. Results are displayed in Table 5.

Table 5: *A Table Displaying Descriptive Statistics.*

		n	**Mean**	**Std. Dev**	**Median**	**Range**
Combined Total	**Frailty (52-item)**	351	.191	.128	.163	0 - .652
	Quality of Life	153	38.27	6.47	40	18 – 48
	Care Hours/Week	318	.83	4.85	0	0 – 74
	Falls	251	.31	1.15	0	0 – 12
	Hospitalisation	283	.44	1.55	0	0 – 17
	Hospital Stay	262	1.05	4.37	0	0 – 35
Male	**Frailty (52-item)**	134	.194	.132	.157	0 - .652
	Quality of Life	60	38.63	6.148	40	18 - 48
	Care Hours/Week	122	1.118	6.88	0	0 - 74
	Falls	101	.43	1.499	0	0 - 12
	Hospitalisation	104	.769	2.345	0	0 - 17
	Hospital Stay	109	.605	6.314	0	0 - 35
Female	**Frailty (52-item)**	217	.190	.126	.165	.006 - .637
	Quality of Life	93	38.04	6.685	40	18 - 48
	Care Hours/Week	196	.646	2.968	0	0 - 35
	Falls	149	.23	.829	0	0 - 6
	Hospitalisation	157	.222	.525	0	0 - 3
	Hospital Stay	173	.655	2.403	0	0 - 21

2.11.3. Test-Retest Reliability

As suggested by Portney and Watkins (2000) a 2-way mixed-effects intra-class correlation with absolute agreement was used to assess the test-retest reliability of the Frailty Index 52-

item. For this analysis to be relevant, two assessments of frailty for each participant within a short period of time (when little frailty change is expected) were required. Therefore the time periods ‘baseline’ and ‘F1’ were used for this analysis as this was the shortest time period available between data collection points (a three month interval between assessments). A total of 164 participants were used in this analysis.

Unlike standard correlation analysis, which assesses general change in trends to assess relationship strength, an absolute agreement intra-class correlation compares values of participant scores at two time periods for exactness (how similar the two scores are). In the context of the FI, the intra-class correlation will assess how similar participant scores are at baseline and after a 3-month period. As frailty developments over an extended period of time, little change is expected over a 3-month period.

An average measures intra-class correlation score of .910 was gained, with a 95% CI ranging .875 to .935, indicating ‘very good’ to ‘excellent’ consistency between the frailty scores from the two time periods. Therefore test-retest reliability was confirmed.

2.11.4. Internal Reliability

As the analysis requires a full data set, only 145 of the 351 participants who took part in the study were eligible for the analysis. Results from the analysis determined that the frailty index possessed a Cronbach’s Alpha score of .817, with an ‘alpha if item deleted’ range score of .799 to .827. Therefore, high internal reliability with low risk of item redundancy was assumed.

2.11.5. Convergent Validity

A correlation analysis was performed to assess the strength of the association between scores gained from the FI52 and the Frailty Phenotype (FP), Frailty Index derived from the Canadian Study of Healthy Ageing (CSHA), Groningen Frailty Index (GFI), Tilburg Frailty Indicator (TFI), Edmonton Frail Scale (EFS), and electronic Frail Scale (eFI). Results are displayed below in Table 6.

Table 6: *A Correlation Analysis between Frailty Scores gained from the Frailty Index (52-item) and Multiple Indices.*

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. FI52	---						
2. FP	.351**	---					
3. CSHA	.570**	.394**	---				
4. GFI	.609**	.273**	.398**	---			
5. TFI	.425**	.428**	.434**	.431**	---		
6. EFS	.611**	.367**	.503**	.519**	.572**	---	
7. eFI	.538**	.275**	.555**	.468**	.531**	.637**	---

*** = significant at the .01 level*

The correlation matrix shows the FI52 to be significantly correlated with all other indices with a .01 level of significance. Therefore convergent validity can be assumed.

2.11.6. Construct Validity

To assess construct validity against Rockwood's (2005) criteria of frailty index validation, a t-test was performed to assess for a significant gender difference in frailty scores, a correlation analysis to assess if frailty was positively associated with age, and linear regressions to determine if frailty predicted quality of life and the number of falls an individual has suffered over a 12-month period was performed.

Results did not find a significant gender difference (t = .407, p>.05), although examination of the mean frailty scores for each gender discovered that men were on average slightly frailer than women, with men averaging a frailty score of .194 compared to the mean frailty score of .189 attributed to women.

The linear regression performed to assess the predictive capabilities of the FI52 discovered that it significantly predicted quality of life (R^2 = .633, F(1, 151), = 101.091, p<.001), the number of falls (R^2 = .056, F(1, 248) = 14.778, p<.001) and hospital admissions (R^2 = .056, F(1, 248) = 14.778, p<.001) an individual has experienced over a 12-month period. In addition, a correlation analysis also discovered a significant positive correlation between frailty and the duration of hospital stay when admitted to hospital (r = .234, p<.001).

The correlation analysis that was performed to assess if frailty was significantly associated with age discovered a significant positive correlation (r = .200, p<.001), indicating that an increase in age was associated with an increase in frailty severity.

2.11.7. Prognostic Validity

To assess the prognostic capabilities of the FI52 a series of Cox Regressions were performed to determine if the FI52 significantly predicted several health outcomes including i) needing care, ii) having a fall, iii) unplanned hospitalisation, and iv) mortality, over a 2-year period.

In the cases in which participants completed assessments for longer than a 2-year period, but the event had not occurred (i.e. did not receive care, did not have a fall etc.), their time score was reduced to 24 months to match the 2-year period for assessment.

Participants were grouped based on their frailty score. The groups accounted for a range of .100 of frailty (i.e. 0.0 to 0.1, 0.1 to 0.2, 0.2 to 0.3, 0.3 to 0.4, and 0.4 to 0.5), with the

exception of the final group, which was specific for participants with a frailty score ranging from 0.5 to 0.7. This was because very few participants possessed a frailty score above 0.5.

In some instances participants opted to not answer questions about the outcomes being assessment. Of the 351 participants used in analyses, 316 answered about the amount of care they receive, 319 provided information about the amount of times they were hospitalised over 12-months prior to their assessment, 347 about the amount of falls they have over the 12-months prior to their assessment, and we possessed information on 347 participants (gained from contacting ExtraCare Well-Being Advisors, or participants directly), as to if participants were still alive or not (we were unable to contact the remaining four participants).

Next to each gradient the number of participants (*n*) categorised within each gradient is displayed. The number of participants changes slightly within each assessment due to varying numbers of participants who completed an assessment in relation to that specific outcome.

This is followed by the coefficient (B) which provides the direction of the association between the predictor (frailty) and the events (which in this analysis is the participant needing care, being hospitalised, having a fall, and/or death). For example, a positive coefficient indicates that as the predictor (frailty) increase, so too will the likelihood of the event occurring. The extent of this association is represented as the hazard ratio (Exp(B)). The hazard ratio compares the likelihood that the event occurs for one group of participants against a comparison group (which will be the 0.0 to 0.1 category for each analysis). For example, if the 0.1 to 0.2 category possesses an Exp(B) score of 3.0 for needing care, this means that participants who possess a frailty score ranging from 0.1 to 0.2 are 3x more likely to need care over a 2-year period compared to participants in the 0.0 to 0.1 category. Results from the Cox Regressions are displayed below in Table 7.

With the exception of mortality, the FI52 significantly predicted all outcomes. Participants in the 0.4 to 0.5 frailty score category are 70x more likely to need care, 4.6x more likely to have a fall, and 4.9x more likely to be hospitalised over a 2-year period compared to participants in the 0.0 to 0.1 frailty category. These findings show that overall as frailty increases, so too does the likelihood of these events occurring. The only contradiction in this is the risk of hospitalisation for participants in the 0.5 to 0.7 frailty score categorisation, in which a decrease in risk was observed when compared to the 0.4 to 0.5 frailty score categorisation. It is, however, likely that this is due to the small sample size in this group.

The Hazard Curve Graphs (displayed below in Figures 2, 3, and 4) represent the likelihood of the 'event' (having a fall, needing care, and hospitalisation) occurring for each frailty category, with the exception of mortality as no predictive capabilities were discovered in the Cox Regression.

The further away the 'accumulative hazard' (y axis) score is from 0, the more people have been subjected to the hazard i.e. the event has occurred (had a fall, been hospitalised, and/or required care). At baseline (0 months) the 'accumulative hazard' score represents all participants. The further away the starting point is from 0, the more participants the event has occurred in. Following this, increases in the line representing each cohort is specific to participants who have had the event occur only. The greater the increase, the more participants the event occurred in.

The duration of each analysis is over 24-months. However, the time duration (x axis) in each graph may not be over a 24-month period, such as the hazard curve examining participants need for care. This is because all participants in whom the event had occurred were before the 24-month point.

Table 7: *Cox Regression Analyses Displaying the Risk of Needing Care, Hospitalisation, and Death over a 2-year Period.*

Outcome	Frailty Gradient	*n*	B	SE	Wald	Df	Sig.	Exp(B)	95% Confidence Interval	
									Lower	Upper
Need Care	**0.0 - 0.1**	95			56.201	5	<.001			
	0.1 - 0.2	105	1.504	1.096	1.884	1	.170	4.498	.525	38.508
	0.2 - 0.3	65	2.512	1.061	5.606	1	.018	12.331	1.541	98.646
	0.3 - 0.4	26	4.125	1.034	15.906	1	<.001	61.875	8.149	469.824
	0.4 - 0.5	17	4.255	1.046	16.532	1	<.001	70.423	9.058	547.515
	0.5 - 0.7	8	4.448	1.084	16.848	1	<.001	85.449	10.217	714.650
Mortality	**0.0 - 0.1**	102			10.404	5	.064		---	---
	0.1 - 0.2	117	11.273	111.506	.010	1	.919	---	---	---
	0.2 - 0.3	71	10.196	111.509	.008	1	.927	---	---	---
	0.3 - 0.4	31	11.627	111.507	.011	1	.917	---	---	---
	0.4 - 0.5	18	12.793	111.506	.013	1	.909	---	---	---
	0.5 - 0.7	8	12.925	111.510	.013	1	.908	---	---	---
Falls	**0.0 - 0.1**	102			20.041	5	.001			
	0.1 - 0.2	116	.542	.287	3.582	1	.058	1.720	.981	3.017
	0.2 - 0.3	72	.912	.299	9.388	1	.002	2.496	1.390	4.480
	0.3 - 0.4	30	.913	.381	5.738	1	.017	2.491	1.180	5.256
	0.4 - 0.5	19	1.536	.371	17.106	1	<.001	4.645	2.244	9.619
	0.5 - 0.7	8	.445	.744	.358	1	.549	1.561	.363	6.711
Hospitalisation	**0.0 - 0.1**	95			23.516	5	<.001			
	0.1 - 0.2	108	.568	.255	4.986	1	.026	1.765	1.072	2.908
	0.2 - 0.3	65	.624	.282	4.891	1	.027	1.867	1.074	3.248
	0.3 - 0.4	26	1.301	.313	17.263	1	<.001	3.674	1.989	6.788
	0.4 - 0.5	18	.863	.390	4.894	1	.027	2.371	1.103	5.094
	0.5 - 0.7	7	1.607	.460	12.215	1	<.001	4.989	2.026	12.289

Figure 2 is displaying the gradual change in the number of participants who received some form of formal care over the 24-month period used in the analysis. The lower frailty gradients show minimal increase (remaining at 0 indicates that the event had not happened to any participants in that cohort, and vice versa), meaning that over the 2-year period very few participants who possessed a frailty score of .300 or less at baseline required formal care over the following 2 years. However, across all cohorts with a frailty score of .300 or above, a dramatic difference is observed, with the majority of participants in each group needing care at some period of the 2-year period, and a large amount already receiving care at their baseline (0 months) assessment.

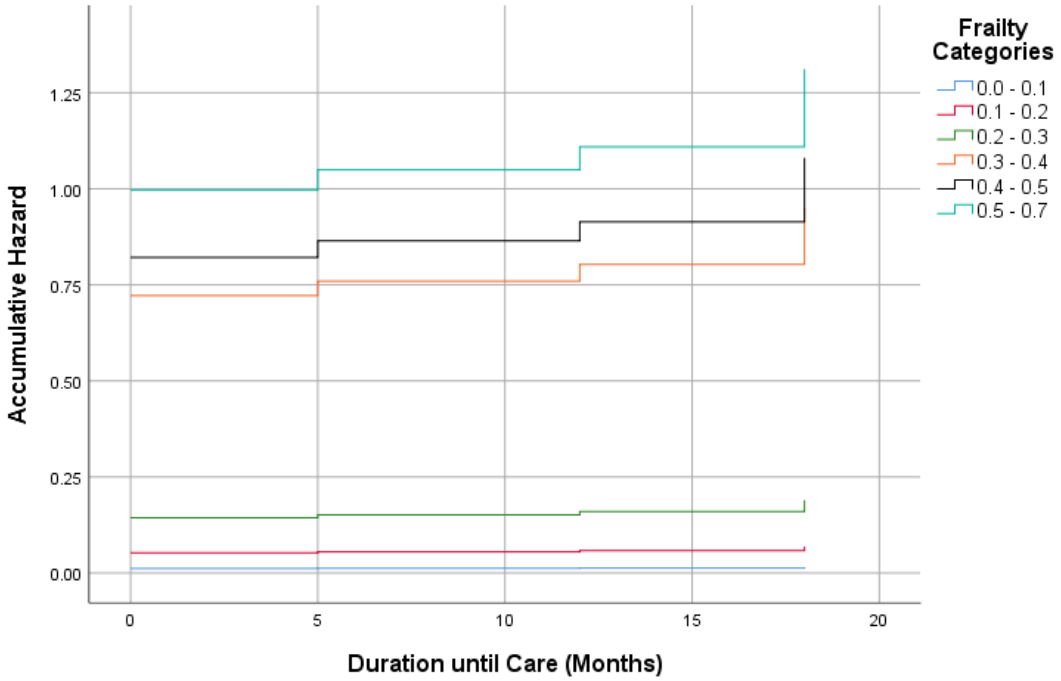


Figure 2: *A Hazard Curve Displaying the Risk of Needing Formal Care over a 2-year Period*

The graph below (Figure 3) is showing a general increase in the risk of having a fall over a 2-year period as frailty increases. However, participants in the frailest condition (participants with a frailty score ranging from 0.5 to 0.7) contradict this trend as they show a similar risk factor as participants with a frailty score ranging from 0.1 to 0.2, although the large difference in same size suggests this is an anomaly. The overall trend is supported by the frailer participants having a fall (the question regarding falls covers 12-months prior to the assessment) at baseline (0 months) compared to more robust individuals.

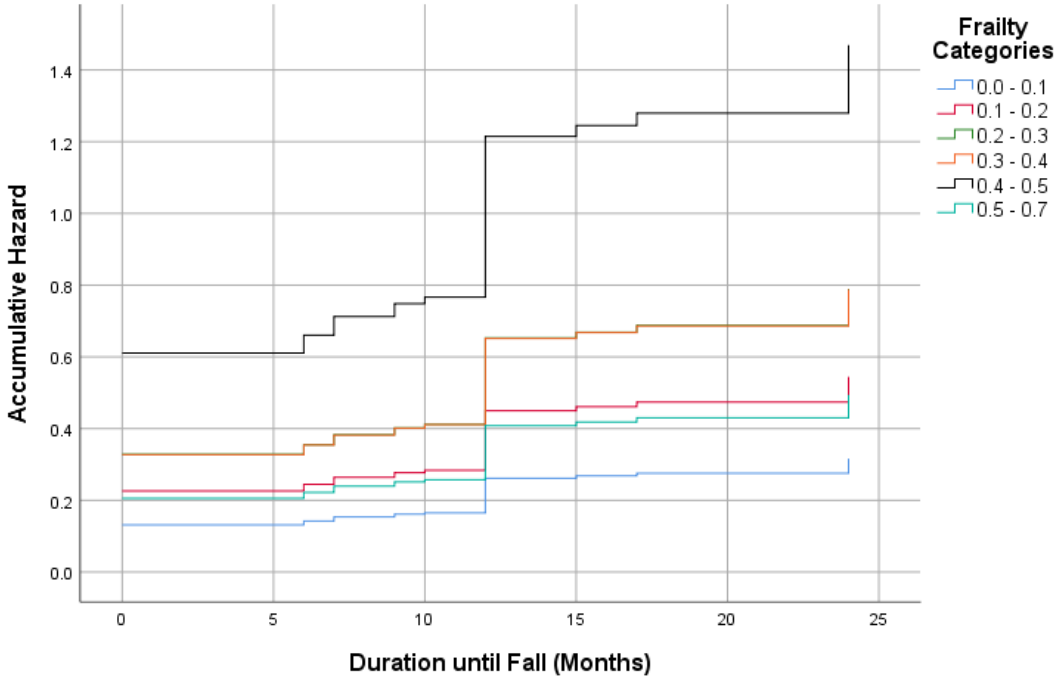


Figure 3: *A Hazard Curve Displaying the Risk of having a Fall over a 2-year Period.*

Figure 4 (see below) shows a general increase in the risk of hospitalisation over a 2-year period as frailty increases. Similar to the risk of having a fall, the frailest participants (frailty score of 0.5 to 0.7) possesses a risk of being hospitalised similar to participants with a frailty

score ranging from 0.1 to 0.2. However, sample strength of the frailest cohort suggests this is also an anomaly.

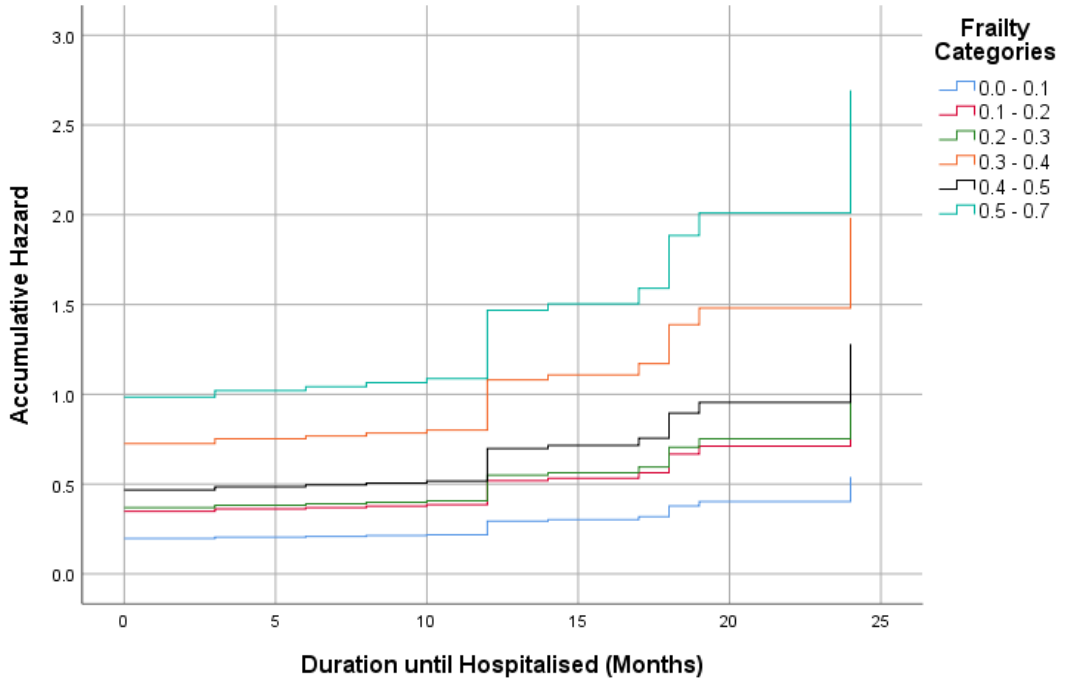


Figure 4: *A Hazard Curve Displaying the Risk of being hospitalised over a 2-year Period.*

2.11.8. Sensitivity and Specificity Assessment using ROC Curves

To assess the sensitivity and specificity of the FI52 in predicting risk of needing care, hospitalisation, and mortality, ROC curves were utilised. The purpose of the ROC curve is to gauge the sensitivity (the proportion of observations that were correctly observed to have experienced the event i.e. true positive rate) and specificity (the proportions of observations that were correctly predicted to have not been observed i.e. true negative rate) of the frailty index in predicting outcomes. When reflected in an ROC graph, the ideal scenario is to observe a graph in which the curve is close to the top left corner as this indicates a high sensitivity and specificity score. Such an outcome would indicate a high probability of true

positive rate and true negative rate. This is reflected in the 'area' score, with higher area scores indicative of this. Results are presented in Table 8.

Table 8: *A Table Displaying the Area under the Curve Analysis Output.*

	AUC	Sensitivity	Specificity	Std. Error	Sig.	95% CI	
						Lower	Upper
Formal Care	.896	.891	.708	.027	<.001	.843	.950
Hospitalisation	.675	.706	.603	.036	<.001	.605	.745
Falls	.641	.679	.552	.032	<.001	.579	.703
Mortality	.770	.650	.272	.045	<.001	.681	.859

The FI52 possessed an Area under the Curve score ranging from .641 to .896 in relation to predicting the outcomes needing formal care, unexpected hospitalisation, risk of having a fall, and mortality, all of which were significant. This means that the FI52 possesses a significantly high positive true rate and true negative rate in relation to predicting these outcomes, and therefore the FI52 is confirmed to being a good model for predicting outcomes (Fawcett, 2006; Marŏco, 2011).

2.12. Discussion

The purpose of this study was to improve and validate the frailty index designed by Holland *et al* (2015) through a combination of standard analytical tests and the validation criteria set by Rockwood (2005), and to confirm the early frailty prognostic capabilities of the frailty index stated by Holland *et al* (2015).

2.12.1. Rockwood's Frailty Validation Criteria

Rockwood (2005) stated that a valid and reliable frailty tool should have a significant positive correlation between frailty scores and chronological age, indicate that frailty is more prevalent in women than men, and be able to significantly predict unexpected hospitalisation and mortality. Results from analyses were only partially consistent with Rockwood's validation criteria: a significant positive correlation was discovered between chronological age and frailty, yet no significant difference was found in frailty severity between men and women. However, when there was no significant difference between genders, as is the case in this study, research has often failed to note a gender difference (Kulminski *et al.*, 2011), and in some cases frailty prevalence has been greater in men than women (Strawbridge, Shema, Balfour, Higby & Kaplan, 1998).

The FI52 significantly predicted risk of unexpected hospitalisation over a 2-year period, but possessed no prognostic capabilities in relation to predicting risk of mortality over a 2-year period, although linear regression and ROC curve did show that the FI52 significantly and accurately predicted mortality. It is possible to attribute the lack of a significant hazard to only a small percentage of deaths within the study. Indeed research assessing the prognostic capabilities of the Accumulation of Deficits model in similar circumstances failed to identify significant prognostic capabilities in relation to predicting mortality (Turusheva *et al.*, 2016).

Overall these findings meet Rockwood's (2005) validation criteria, and in areas where criteria were not met, there is sufficient evidence to justify non-significant results without questioning the validity and reliability of the FI52.

2.12.2. Predicting Early Frailty Risk Factors

According to Holland *et al* (2015) the original Frailty Index provided a means by which care requirements could be predicted based on frailty score gained from the model. This was designed to ensure that individuals who are suggested to need care based on their frailty severity receive the necessary help to maintain independence. With the incorporation of the new variables it was important to ensure the predictive capabilities of the tool were not lost. Results from the regressions confirmed the FI52 maintained the ability to predict care, with the outcome of predicting future risk of care also confirmed. In addition to this, it was also confirmed that the FI52 possessed the ability to predict future risk of having a fall, further highlighting the capabilities of the FI52 in predicting early risk factors. The importance of such conclusions is highlighted in previous research. For instance, having a fall is also linked to risk of osteoporotic and hip fractures (Cummings-Vaughn & Gammack, 2011), and therefore identifying the risk of these events occurring allows for procedures to be implemented to minimise that risk. Therefore the FI52 should be seen as a suitable tool for frailty assessment and frailty interventions.

2.13. Limitations

The sample for this study lacked the necessary amount of participants required to run meaningful analyses in relation to end-of-life outcomes associated with a valid frailty index. For instance, only eight participants possessed a frailty score above .5 (according to Rockwood, & Mitnitski, (2006), frailty scores of .6 and above are indicate of near end-of-life outcomes within a 6-month period) and were therefore unable to consider the prognostic capabilities of Holland *et al's* (2015) revised Frailty Index in relation to predicting death.

As this model uses an accumulation of deficits approach (Rockwood *et al.*, 2005), the 52-item Frailty Index is requires a substantial amount of time to complete. This reduces the real-life applicability of the instrument.

Finally, the suitability of this Frailty Index for the current project requires further evidence. Although the model can be considered valid and reliable, it has yet to be compared to other frailty indices in relation to its performance regarding its prognostic capabilities. Until this task is complete, we cannot be sure that this index is the ideal instrument for the current thesis.

2.14. Conclusion

The purpose of this study was to improve Holland *et al's* FI (which became a 52-item index) and validate the tool. As the FI52 met the requirements set by Rockwood (2005), confirmed the prognostic capabilities stated by Holland *et al* (2015), and fulfilled standard analytical assessments, it can be concluded the FI52 is a highly reliable and valid method of frailty assessment. The FI52 offers strong prognostic capabilities in relation to early frailty outcomes that in some cases (such as predicting care) research has rarely, if at all, attributed to other frailty indices.

In addition, the confirmation of strong prognostic capabilities in relation to early frailty outcomes (risk of a fall and needing care), that are not attributed to other frailty assessment tools, indicate the FI52 provides a greater capacity for assessing the need to intervene on frailty progression.

2.15. Study 2: Improving the Frailty Index

2.16. Introduction

The conclusion drawn in Study 1 is that the 52-item Frailty Index is a valid and reliable tool that, with the exception of a gender difference and predicting death, met standard validation procedures (Pallant, 2011), Rockwood's (2005) validation criteria, confirmed Holland's (2015) assertions that the tool significantly predicted the need for formal care, and also predicted the risk of having a fall (Clegg *et al.,* 2016). However, it was also noted that in its current format, completing the Frailty Index 52-item is a time-consuming process, and therefore lacks practical applicability. Therefore the focus of Study 2 is to reduce the Frailty Index into a shortened version to improve the practicality of completing a frailty assessment using this tool, and ensuring that the high standards of reliability and validity of the 52-item version are not lost during the process of variable reduction. This will be confirmed by comparing the prognostic capabilities of the shortened Frailty Index to the 52-item model. To overcome further limitations noted in Study One1 Study 2 will also compare the prognostic capabilities of the shortened version against multiple other indices: the Accumulation of Deficits (Rockwood *et al.,* 2005), Frailty Phenotype (Fried *et al.,* 2001), Groningen Frailty Index (Peters *et al.,* 2012), Tilburg Frailty Indicator (Gobbens *et al.,* 2011), electronic Frailty Index (Clegg *et al.,* 2016), and the Edmonton Frail Scale (Rolfson *et al.,* 2006) to determine how well the shortened Frailty Index operates against other indices.

2.17. Aims

1. To produce a short version of the Frailty Index 52-item that maintains the reliability and validity of the original instrument but which takes less time to administer. Then

compare the frailty scores gained from the shortened Frailty Index against the FI52 in both a cross-sectional comparison and a comparison of how frailty changes over time.

2. To assess the reliability and validity of the shortened Frailty Index.
3. To compare the prognostic capabilities of the shortened Frailty Index against the FI52 and multiple other indices.

2.18. Method

The participants and measures used, ethical guidelines, and procedure followed are the same as those used in Study 1.

2.19. Data Analysis

2.19.1. Variable Reduction - Sample

To reduce the number of variables within the 52-item Frailty Index a Principal Components Analysis (PCA) was performed. A PCA requires full data sets for participants to be eligible for analysis. Of the 351 participants used in this study, only 143 fulfilled this requirement. According to Pallant (2011) determining a sufficient sample size for a PCA is calculated by multiplying the number of variables in the analysis by at least 5 (optimally 10) participants per variable), and therefore 143 participants is insufficient for the analysis. To overcome this issue four scenarios are considered as potential pathways to increase sample size for the analysis (which are discussed in the results section).

- **Scenario 1:** Conduct PCA using only the participants with complete data sets, which is 143 participants.

- **Scenario 2:** Remove the variables 'grip strength' and 'exhaustion' from the analysis due to high levels of missing data (with grip strength and exhaustion possessing 71.6% and 55% missing data respectively). These two variables are considered key frailty markers are frailty. For instance, Syddall, Cooper, Martin, Briggs, and Sayer (2003) stated that grip strength is a more important factor in frailty than chronological age. Furthermore, feelings of exhaustion are strongly associated with physical inactivity, a significant contributor to physiological frailty (Chen, Mao, & Leng, 2014). Both assessments are also used in the two main clinical frailty indices, the Frailty Phenotype (Fried *et al.,* 2001), and the CSHA Frailty Index (Rockwood *et al.,* 2005). Therefore, these two markers are given an *a priori* status and will be retained in the shortened version of the 52-item Frailty Index irrespective of analytical outcome. This would increase the valid cases for analysis to 204 participants.
- **Scenario 3:** Conduct analyses using all participant data, including incomplete data sets using a pairwise correlation analysis[2]. This would result in a range of 206-351 participants being used in analysis depending on the variables analysed.
- **Scenario 4:** Perform a multiple imputation on the missing data. This would increase the sample size to a suitable 351 participants.

In Scenario 1, four variables (eating, bed, telephone, and medication) were removed as there was no variance in participant answers and were therefore referred to as FI48 in the analysis. In Scenario 2, following the removal of the variables exhaustion and grip strength, a third variable was removed (telephone) due to a lack of variance in participant answers. Therefore,

[2]Pairwise analysis performs a correlation analysis individually between two variables, this results in varying sample size for each analysis but also allows for all data collected to be used in analysis.

Scenario 2 was referred to as FI49. In Scenario 3, no variables were removed from the analysis, and is therefore referred to as FI52. Finally, Scenario 4, in which data was imputed to increase the sample size, no variables were removed from the matrix, and was therefore referred to as IFI52.

To determine which scenario to pursue, a correlation matrix for each scenario was built and the correlation bias (which is an assessment of error in analysis, higher scores are indicative of more bias) and correlation Root Mean Square Error (RMSE, the variation of data between correlation matrices) was calculated and compared between each matrix. To minimise error in deriving the correlation matrices the statistical programme 'R' was used to build the matrices as 'R' allows for multiple forms of correlation to be performed and built into a single matrix. For instance, between dichotomous outcomes (such as being diagnosed with diabetes or not) a polychoric correlation was performed, between a dichotomous and multi-scoring marker (such as walking speed, which possesses five scores ranging from 0 to 1) a polyseries correlation was performed, and between two continuous scoring markers, a Pearson correlation was performed. These different forms of correlation were performed simultaneously and merged into a single correlation matrix. The correlation bias and RMSE scores for each matrix were compared. Results are displayed below in Table 9.

Table 9: *The Correlation Bias and Root Mean Square Error between the Correlation Matrices Derived from the Four Scenarios.*

	Bias				**Root Mean Square Error**			
	FI48	**FI49**	**FI52**	**IFI52**	**FI48**	**FI49**	**FI52**	**IFI52**
FI48	---	.167	-.048	-.021	0	.323	.517	.516
FI49	-.167	---	-.215	-.188	.323	0	.514	.501
FI52	.048	.215	---	.027	.517	.514	0	.049
IFI52	.021	.188	-.027	---	.516	.501	.049	0

** RMSE Scores lower than .05 indicates little variation between matrices.*

** Bias scores lower than 0.5 indicate low error*

Low bias was confirmed when comparing the FI48 to the FI52 and IFI52 matrices. In addition, low bias was discovered when comparing the FI52 and the IFI52. All other comparisons had high correlation bias scores, indicating a high risk of error. However, examination of the RMSE comparisons show that only the comparison between FI52 and IFI52 possess a low RMSE score. These two scenarios (FI52 and IFI52) possess the highest amount of participants, which suggests that the loss of participants in the other two scenarios (FI48 and FI49) resulted in a substantial loss variation in participant scores. Therefore the scenarios FI48 and FI49 were excluded from consideration for the variable reduction analysis. Finally, the low RMSE scores between the FI52 and IFI52 scenarios indicate that there was little variance between the two correlation matrices, and therefore performing the multiple imputation (which is a controversial process as it fills data gaps by considering patterns in participant answers despite individuals being complex and unpredictable) to increase sample size will have minimal impact on the PCA. Therefore, the FI52 scenario was confirmed as the ideal scenario to use for performing the PCA analysis.

2.19.2. Variable Reduction - Analysis

A correlation analysis will be performed to assess for multicollinearity (two or more items so strongly correlated it is concluded they assess the same construct). Correlation scores of .800 and above represent item redundancy (Pallant, 2011). In the event item redundancy is discovered, the variable which possesses less variation in scoring (for instance, a scale variable will be favoured over a dichotomous variable) will be removed from the model.

Following this, the KMO measure of Sampling Adequacy and Bartlett's Test of Sphericity scores will be considered. According to Pallant (2011) a KMO score of .600 and above and a significant Bartlett's test score are pre-requisites for performing a PCA analysis.

The final consideration prior to the PCA will be to consider the communality scores of variables. According to Pallant (2011), variables with a communality score of less than .300 should be removed from the analysis (and model) as they do not group with other variables.

A Horn's Parallel analysis will be performed to determine the number of components to be used in the PCA. The PCA will be performed using a varimax rotation. The pattern matrix produced from the analysis will be used to determine how variables group together into components, and the strength of the variable in the component (referred to as a loading power). According to Pallant (2011) variables with a loading power less than .400 should be removed from the model, and this will be the parameter to determine which variables should remain in the model and which should be removed.

After the PCA, variables removed were reviewed to see if they are warranted an *a priori* status (such as grip strength and feelings of exhaustion) based on literature and should therefore be retained in the model despite contradicting conclusions within analytical findings.

Following this, the remaining variables were reviewed for generic overlap. For instance, the ability to walk, walk 100 metres, and walking speed are expected to have significant overlap in terms of what they assess. To determine if any of these variables should be removed, a correlation analysis will be performed, with a correlation significance of $p<.001$ required to proceed with a variable removal. To decide which variable(s) will be removed, evidence based on literature will be considered.

Finally, to address the limitation (as discussed in Study 1) of time efficiency associated with the 52-item Frailty Index, variables will be reviewed based on assessments for each variable, and if possible, removing the variable for a proxy variable that is representative of the original variable but allows for assessment in a shorter period of time. To ensure the proxy variable is representative of the variable it is replacing a correlation analysis will be performed between the two variables, and a significance of $p<.001$ required to proceed with the replacement.

For reducing the number of variables within the 52-item Frailty Index based on generic overlap between variables, and time efficiency in completing assessments. It is possible that performing a correlation analysis will not be viable as variables reviewed will be a specific component of the whole assessment (e.g. the variables 'happy' and 'enjoy life' are part of the measure used to assess the 'depressed' marker). In the event this occurs, the extent to which the whole marker (e.g. depression) is represented by the specific item assessments (e.g. happy and enjoy life) will be the determining factor in deciding which variable(s) should be removed/retained.

2.19.3. Reliability and Validity Analyses

To assess the consistency of frailty scores gained between the shortened Frailty Index and the FI52 an intraclass correlation was performed to provide a cross-sectional comparison, and a Growth Model was used to assess the change in frailty between the two versions over a 2-year period (only a small number of participants (six) completed an assessment at each of the five assessment points over the 2-year period being analysed, and therefore a Repeated-Measures ANOVA was not an applicable method of analysis). Finally, the mean and maximum individual frailty score change at each time point between the two versions of the frailty index

was calculated. In addition, outliers were assessed using an interquartile range of 3.0 (scores that are greater than 3.0x the range from the 25% quartile to the 75% quartile) to ensure results were not skewed. Finally, the cross-sectional RMSE between the two versions of the frailty index at each time point was calculated to ensure the individual variation in frailty scores between the FI52 and FI36 did not significantly vary.

Following this, the reliability and validity analyses used to validate the FI52 (see Study 1 Data Analysis) were implemented on the shortened Frailty Index.

2.19.4. Quality Comparison Assessment

Using Cox Regressions the prognostic capabilities of the shortened Frailty Index were compared to the FI52 to ensure that no significant prognostic capabilities were lost during the variable reduction process. In addition, the FI36 was also compared against six frailty indices recreated from data collected during this thesis. The indices are: the Frailty Phenotype (FP), the Frailty Index derived from the Canadian Study of Healthy Ageing (CSHA), Groningen Frailty Index (GFI), Tilburg Frailty Indicator (TFI), Edmonton Frail Scale (EFI), and the electronic Frailty Index (eFI). Details of each index are presented in Study 1 Table 2 under Data Analysis.

If conclusions show that the shortened Frailty Index was equal or superior to other indices in predicting outcomes this would further support the use of the shortened Frailty Index in the current thesis.

2.20. Results

2.20.1. Item Reduction

Assessment of Multicollinearity

The correlation analysis did not discover any correlations between variables that indicate multicollinearity (i.e. above .800), and therefore no items were removed from the model.

Horn's Parallel Analysis

The Horn's Parallel analysis identified three components in the 52-item frailty index: Component 1 possessed an eigenvalue of 22.891 and a bias of 2.667. Components 2 and 3 possessed adjusted eigenvalue scores of 2.768 and 2.802 with bias scores of 2.337 and 2.093 respectively. Based on these findings, the PCA performed for variable reduction was conducted using a three component structure.

Principal Components Analysis

A KMO Measure of Sampling score of .601, and a significant Bartlett's Test of Sphericity (p<.001) were confirmed, indicating the PCA was a viable method of analysis. Finally, all variable communality scores were above .300 and were therefore retained for the analysis. Results are displayed below in Table 10 and components detailed below.

A total of nine variables (restless sleep, asthma, arthritis, blood pressure, osteoporosis, cancer, Parkinson's disease, poor eyesight, and self-reported hearing) did not possess a loading power above the .400 threshold, and therefore were removed from the Frailty Index.

Table 10: *The 3 Level Component Structure gained from the Principal Components Analysis.*

	Component 1	Component 2	Component 3
Walking 100	.665		
Chair Get Up	.604		
Stairs	.832		
Dressing	.850		
Walking	.752		
Bathing	.869		
Eating	.570		
Bed	.753		
Toilet	.674		
Hot Meal	.853		
Shopping	.846		
Telephone	.711		
Medication	.777		
Money	.742		
Housework	.860		
Self-Reported Health	.564		
Happy	.562		
Enjoy Life	.581		
Date	.420	-.415	
Month	.502	-.694	
Year	.458	-.660	.405
Weekday		-.852	
Immediate Recall		-.544	
Delayed Recall	.414		
Coronary Heart Disease (CHD)			.668
Diabetes			.610
CHD & Diabetes Joint Effect			.698
Stroke			.411
Lung Disease			.550
Psychiatric		.543	
Dementia			-.887
Hip Fracture			.661
Joint Replacement		.518	
Exhaustion	.665		
Body Mass Index		.451	
Sit-to-Stand Speed	.617		
Polypharmacy	.526		
Depressed	.644		
Fluency	-.558	.492	
Mini Mental State		.473	
Walking Speed	-.837		
Weekly Exercise	-.533		
Grip Strength	-.535		

All blank sections indicate a loading power <.400

Component 1: *Physical Ability*

The primary loading variables within Component 1 are a combination of physical assessments designed to assess muscle density and the ability to perform daily tasks. Three variables (walking speed, weekly exercise, and grip strength) possessed a negative loading score. This is because their scoring system is opposite to the remaining variables in the component. That is, higher scores for these three variables indicate robustness, whereas for the variables with a positive loading power, higher scores are indicative of frailty. Therefore component one was categorised as physical ability.

Component 2: *Cognitive Functioning*

There are fewer primary loading variables attributed to Component 2 compared to component one. With the exception of the variables joint replacement and body mass index, all variables loaded into this component two are attributed to different cognitive tasks. However, as both joint replacement and body mass index possess secondary loading powers (loading scores lower than .600) we can consider these two variables as outliers in determining the component. Therefore, component 2 was categorised as cognitive functioning.

Component 3: *Comorbidity*

Component three is comprised of a variety of medical ailments, and therefore is categorised as comorbidity.

Assessing Variables for Overlap

The second stage of variable reduction was to examine the variables within the frailty index to determine if overlap was present from a practical sense. A total of four considerations were made:

1. In the first instance three variables were reviewed: ‘walking 100 (metres), ‘walking’, and ‘walking speed’.
2. The second consideration was between the two variables assessing the ability to stand up from a sitting position (‘Chair Get Up’) and the speed in which this action is performed (‘Sit-to-Stand speed’)
3. The third comparison was between the objective assessment of dementia, the MMSE (Mini Mental State Examination), and the ability to correctly state the date, with assessments of ‘fluency’ and ‘attention’ d ‘attention’ (the ability to accurately detail the day, date, month, and year).
4. The fourth and final consideration was between a full examination of depressive symptomology (which is a full assessment using the HADS) and two variables ‘happy’ and ‘enjoy life’ (two single item assessment variables from the HADS).

From the three variables reviewed in the first instance (walking 100 metres, walking, and walking speed), walking speed is favoured as the variable to retain. The variable assessing the ability to walk across a room (walking) is used as part of the Timed Up-and-Go (TUG) test. In this test the individual has to stand from a sitting position, walk 3.5 metres, then walk back to the chair and sit down. This test is used in considering the physical capabilities of an individual in frailty assessment (Savva *et al.,* 2012). However, in Holland’s Frailty Index, this is split into two separate assessments, with the ability and speed to stand up being the second variable (although retention of both variables is the second consideration in the variable

reduction process). This means, the ability to walk across a room is specifically in consideration of the 7 metres of the TUG test. However, the walking speed assessment is over a distance of 7-metres and therefore reduces the need to consider the ability to walk 7-metres and also offers more variation in assessment (a 5-point likert scale of walking speed, whereas the variable walking is dichotomous).

With regards to considering the ability to walk 100 metres against walking speed, a systematic review by Graham, Ostir, Fisher, and Ottenbacher (2008), showed that walking speed was the primary consideration (between walking speed and distance walked) in assessing the risk of outcomes such as hospitalisation, falls, needing care, mobility, disability, and mortality. It is therefore reasonable to conclude that between walking speed and distance, walking speed is the primary factor in determining physical health.

In considering which assessment, between the ability to stand from a sitting position against the speed in which this action is completed, the speed in which an individual can stand is favoured. This is because the speed in which an individual can stand from a sitting position (paired with the speed in which an individual walks) forms the basis for the TUG test previously discussed. This variable also possesses greater variation compared to the ability to stand. Furthermore, there is significant overlap in terms of the assessment criteria between the two variables. That is, if the individual requires the arms of the chair to stand, both variables would score 1. Therefore, the sit-to-stand variable also considers the ability to stand without using an aid. Based on the evidence reviewed, the ability to stand from a sitting position is removed from the Frailty Index and the speed at which the individual stands is retained.

The third and final consideration between overlapping variables is between the Mini Mental State (MMSE), assessments of fluency (naming as many animals as possible within a minute)

and attention (the ability to correctly state the day, week, month, date, and the ability to repeat three words), and a medical diagnosis of dementia. Of the variables under consideration, MMSE and the medical assessment of dementia are reviewed for removal. This is because the assessments of fluency and attention account for 37% of MMSE scoring. In addition, the assessment of MMSE is used as a clinical assessment for early Dementia (Brodaty *et al.*, 2016). Therefore, it is reasonable to conclude that retaining the variables MMSE and Dementia offers little benefit beyond what is gained from the variables assessing fluency and attention.

The fourth and final variable identified as a potential item for removal is the assessment of depressive symptomology. There are currently two items within the Frailty Index, 'happy' and 'enjoy life', which account for 29% of the items used in assessing depressive symptomology and therefore present a plausible substitute for the complete measure. Therefore, the assessment of depressive symptomology can be removed from the index.

A total of six variables were identified as candidate items to be removed from the Frailty Index. As so far, four have been removed (Chair Get Up, Dementia, MMSE, and Depressive Symptomology) as suitable shorter versions of these assessments have been identified. There remains two candidate items considered for removal, walking and walking 100, with walking speed considered a suitable proxy assessment. However, as they are designed to assess different aspects of physical capability, a correlation analysis is required to confirm the overlap between these variables is substantial enough to warrant their removal.

Walking speed possesses a highly significant correlation with the ability to walk across a room ($r = .459$, $p<.001$) and the ability to walk 100 metres ($r = .456$, $p<.001$). Therefore, the variables 'walking' and 'walking 100' were removed from the Frailty Index.

This means that evaluating variables for overlap a total of six variables (walking, walking 100, chair get up, MMSE, dementia, and depressive symptomology) were removed from the Frailty Index.

Removed Variables Warranting an 'a priori' Status

Of all variables removed from the Frailty Index based on the findings of the PCA, none were considered for reintegration as they did not warrant an *a priori* status.

Assessing Variables for Equality in Time Requirements

After evaluating the variables retained in the Frailty Index, none of the variables require a significant amount of time to assess, and therefore no adjustments were made based on considerations to time requirements.

Following the completion of the PCA a total of nine variables (restless sleep, asthma, arthritis, blood pressure, osteoporosis, cancer, Parkinson's disease, eyesight, and self-rated hearing) were removed from the frailty index as they did not possess a sufficient loading power to warrant their retention. Following this, a further six items (walking, walking 100, chair get up, dementia, MMSE, and depressive symptomology). No further amendments were made based on considerations of warranting removed variables an *a priori* status or contemplating methods for improving the time requirements for completing the frailty assessment. This means that a total of 16 variables were removed from the revised version of Holland *et al's* (2015) Frailty Index, making the shorter version a 36-item model (FI36).

2.20.2. Assessing the Consistency between the FI52 and FI36 Frailty Scores.

An intra-class correlation (ICC) with absolute agreement was performed to determine if both indices produced similar frailty scores. Results from the ICC provided an intra-class correlation score of .974 with a 95% confidence interval range of .967-.979. This indicates the FI36 produces near identical frailty scores to the FI52.

2.20.3. Assessing Change over Time in Frailty between FI52 and FI36.

A comparison of frailty change over time was completed between the original 52-item Frailty Index and the 36-item version produced from the variable reduction procedure above. However, due to participant drop-out and further recruitment in the two larger projects in which data was collected 'Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and The ExtraCare Charitable Trust' (Holland *et al.*, 2015), and the on-going study 'Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and The ExtraCare Charitable Trust – a follow-up' (as discussed in Table 1) observed in data collection points a repeated-measures ANOVA was not usable as only six participants would have been eligible, and therefore a growth-modelling curve (GMC) was used. This was done using data from Baseline to the 2-year point, which contained a total of five assessment points. To ensure the GMC was assessing actual frailty change and not merely cross-sectional differences, participants were only included in the analysis if they had completed assessments on at least three of the five occasions. This resulted in 161 participants being eligible for the analysis, with 138 assessments at baseline (0 months), 140 assessments at F1 (3 months), 147 assessments at F2 (12 months), 127 assessments at F3 (15/18 months), and 22 assessments at F4 (24 months).

As shown below in Figure 5, analysis found that the FI36 consistently produced a higher frailty score than the FI52 with the exception of the F4 time period. However, the difference in frailty scoring between the two models was not significant ($t = .722$, $p>.05$). Furthermore, there was no significant group by time interaction ($t = -.829$, $p>.05$) which suggests that there is no significant difference in terms of how the two models show frailty change over time (a 2-year period). These findings indicate that the 36-item Frailty Index produces similar severity scores to the 52-item model and that it produces a similar trajectory of change over time.

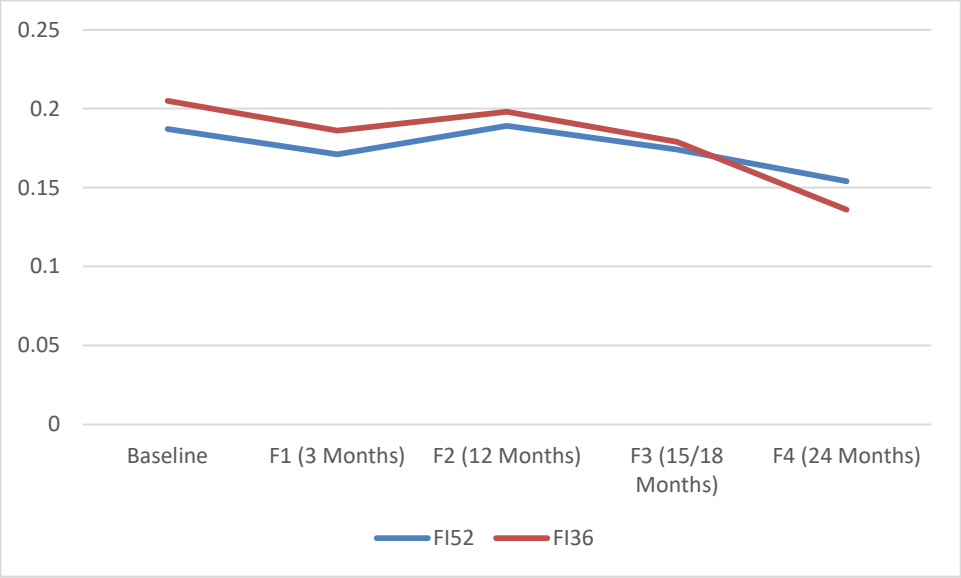


Figure 5: *A Graph Displaying the Change in Frailty over a 2-Year Period from Scores gained from the FI52 and FI36.*

2.20.4. Assessing the Difference in Variation between the FI36 and FI52 scores.

To confirm there was no significant change in variation when reducing the FI52 to the FI36 version the Root Mean Square Error (RMSE) was calculated between scores derived from the two models at each time point up to the 2-year period of assessment, with RMSE scores below 0.5 considered suitable to conclude minimal change in variation. All participant

assessments up to the 2-year period were used in this analysis (participant numbers are presented in the table below).

In addition, the mean and maximum frailty change between the two models was calculated, and outliers assessed by using an interquartile range of 3.0 (scores that are 3x greater than the range from the 25% quartile to the 75% quartile score) to determine if data possessed outliers that required removing. Results are displayed below in Table 11.

Table 11: *The Mean and Maximum Frailty Difference, and RMSE between Cross-Sectional FI52 and FI36 Frailty Scores.*

	n	**Mean Frailty Diff (+/-)**	**Max Frailty Diff (+/-)**	**Outliers**	**RMSE**
Baseline	184	.018	.166	11	.036
F1 (3 months)	183	.013	.162	3	.040
F2 (12 months)	160	.006	.180	12	.037
F3 (15/18 months)	162	<.001	.177	6	.034
F4 (24 months)	88	.002	.185	1	.039

Examination of Table 11 shows a small number of outliers were identified at each assessment point and were subsequently removed from the analyses. Results also show a small difference in the average frailty scores derived from the FI52 and FI36. In addition, all RMSE scores were below .05, indicating similar levels of variation in participant scoring between the two models. These findings suggest that the variable reduction process had a minimal impact on the variation of frailty scores between the two models.

These findings, paired with conclusions from the cross-sectional intra-class correlation comparison indicate the variable reduction process did not significantly alter the variability of frailty scores, and that the FI36 produces similar frailty scores as the FI52 and a similar trajectory of change over time.

2.20.5. Test-Retest Reliability

An intra-class correlation was performed to assess the test-retest reliability of the FI36 over a 3-month period. As frailty is a progressive development it is expected that little change would occur over this period of time. Results from the analysis discovered an intra-class correlation of .920, with a 95% confidence interval range of .887-.943, indicating a minor change in frailty score.

2.20.6. Internal Reliability

A Cronbach's Alpha analysis was performed to determine the internal reliability of the model. An Alpha score of .811 was gained, with an 'alpha if item deleted' range of .792-.812, indicating high internal reliability with low risk of item redundancy (Pallant, 2011).

2.20.7. Concurrent Validity

To assess the concurrent validity of the FI36 against that observed in Study 1 for the FI52, a series of linear regressions were performed to assess if the FI36 significantly predicted amount of formal care an individual received (Holland *et al.,* 2015), quality of life (Kojima *et al.,* 2016), and falls (Clegg *et al.,* 2013). Results are displayed below in Table 12.

Table 12: *A Table Displaying the Predictive Capabilities of the FI36.*

	n	**R^2**	**F**	***p***	**95% Confidence Interval**	
					Lower	**Upper**
Formal Care	317	.089	30.754	<.001	6.461	13.566
Falls	250	.035	8.882	.003	.506	2.476
Quality of Life	153	.381	92.861	<.001	-42.566	-28.081

Results from the analyses discovered that, like the FI52, the FI36 significantly predicted amount of formal care an individual receives falls, and quality of life.

2.20.8. Convergent Validity

The correlation analysis between the Frailty Phenotype (FP), CSHA Frailty Index (CSHA), Groningen Frailty Index (GFI), Tilburg Frailty Indicator (TFI), Edmonton Frailty Scale (EFS), and electronic Frailty Index (eFI) frailty assessment tools (see Table 2), are presented below in Table 13.

Table 13: *A Correlation Matrix Assessing the Convergent Validity of the FI36.*

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. FI36	---						
2. FP	.333**	---					
3. CSHA	.625**	.394**	---				
4. GFI	.531**	.273**	.398**	---			
5. TFI	.403**	.428**	.434**	.431**	---		
6. EFS	.645**	.367**	.503**	.519**	.572**	---	
7. eFI	.510**	.275**	.555**	.468**	.531**	.637**	---

*** = significant at the .01 level.*

Table 11 shows that the FI36 significantly correlated with all other indices assessed with a significance level of .01 and therefore convergent validity was assumed.

2.20.9. Prognostic Validity

As confirmed in Study 1, the FI52 was significantly able to predict future risk of need for care, hospitalisation, and falls over a 2-year period. Therefore to confirm prognostic validity (see Study 1 Data Analysis for detailed description) the FI36 should possess similar prognostic attributes. Results from the Cox Regressions are displayed below in Table 14.

With the exception of death, the FI36 significantly predicted all outcomes, with the frailest of participants 80.05x more likely to need formal care, 2.38x more likely to have a fall, and 3.9x more likely to be hospitalised over a 2-year period. Graphical representation and interpretation (in the form of hazard curves) of the significant findings is displayed below in Figures 6, 7, and 8.

Figure 6 presents a distinction between frailty gradients in terms of the risk of needing care over a 2-year period, with pre-frail participants (frailty score of 0.080 to 0.25) possessing no additional risk of needing care compared to robust individuals, indicating that despite the progression of frailty, pre-frail participants are still able to maintain their independence. However, gradients 0.2 to 0.3 (where participant frailty categorisation changes from ‘pre-frail’ to ‘frail’) a significant increase in risk of needing care is observed. The proceeding gradient (0.3 to 0.4) also shows a small increase in risk of needing care compared to the previous gradient, but not to the extent shown between the pre-frail and frail states. Finally, a large increase in risk of needing care is shown for participants scoring 0.4 and above in terms of frailty severity, with many participants within these categories already receiving formal care at their baseline assessment (see the large drop at 0 months). An overview examination of this hazard curve would indicate that a significant increase in the risk of needing care is observed for every increase in frailty of 0.2.

Table 14: *A Table Displaying the Prognostic Capabilities of the FI36.*

	Frailty Category	*n*	B	SE	Wald	Df	Sig.	Exp(B)	95%CI	
									Lower	Upper
Need Care	**0.0 - 0.1**	91			53.090	5	<.001			
	0.1 - 0.2	110	1.170	1.118	1.095	1	.295	3.222	.360	28.832
	0.2 - 0.3	45	2.305	1.095	4.427	1	.035	10.024	1.171	85.817
	0.3 - 0.4	30	3.678	1.042	12.470	1	<.001	39.569	5.138	304.733
	0.4 - 0.5	18	4.226	1.042	16.439	1	<.001	68.648	8.876	528.184
	0.5 - 0.8	12	4.383	1.057	17.193	1	<.001	80.048	10.085	635.637
Death	**0.0 - 0.1**	97			14.754	5	.011			
	0.1 - 0.2	119	9.935	88.927	.012	1	.911	---	---	---
	0.2 - 0.3	51	10.191	88.928	.013	1	.909	---	---	---
	0.3 - 0.4	34	10.337	88.931	.014	1	.907	---	---	---
	0.4 - 0.5	19	12.197	88.927	.019	1	.891	---	---	---
	0.5 - 0.8	13	11.011	88.931	.015	1	.901	---	---	---
Falls	**0.0 - 0.1**	97			18.837	5	.002			
	0.1 - 0.2	119	.570	.302	3.563	1	.059	1.768	.978	3.194
	0.2 - 0.3	51	.950	.336	8.004	1	.005	2.586	1.339	4.996
	0.3 - 0.4	33	1.018	.374	7.389	1	.007	2.767	1.328	5.764
	0.4 - 0.5	19	1.565	.396	15.642	1	<.001	4.781	2.202	10.382
	0.5 - 0.8	14	.865	.513	2.845	1	.092	2.375	.869	6.484
Hospitalisation	**0.0 - 0.1**	91			25.848	5	<.001			
	0.1 - 0.2	108	.706	.289	5.980	1	.014	2.025	1.150	3.565
	0.2 - 0.3	46	1.013	.327	9.602	1	.002	2.754	1.451	5.226
	0.3 - 0.4	30	1.507	.332	20.548	1	<.001	4.511	2.352	8.653
	0.4 - 0.5	18	1.351	.400	10.800	1	.001	3.725	1.700	8.161
	0.5 - 0.8	12	1.361	.429	10.063	1	.002	3.901	1.682	9.044

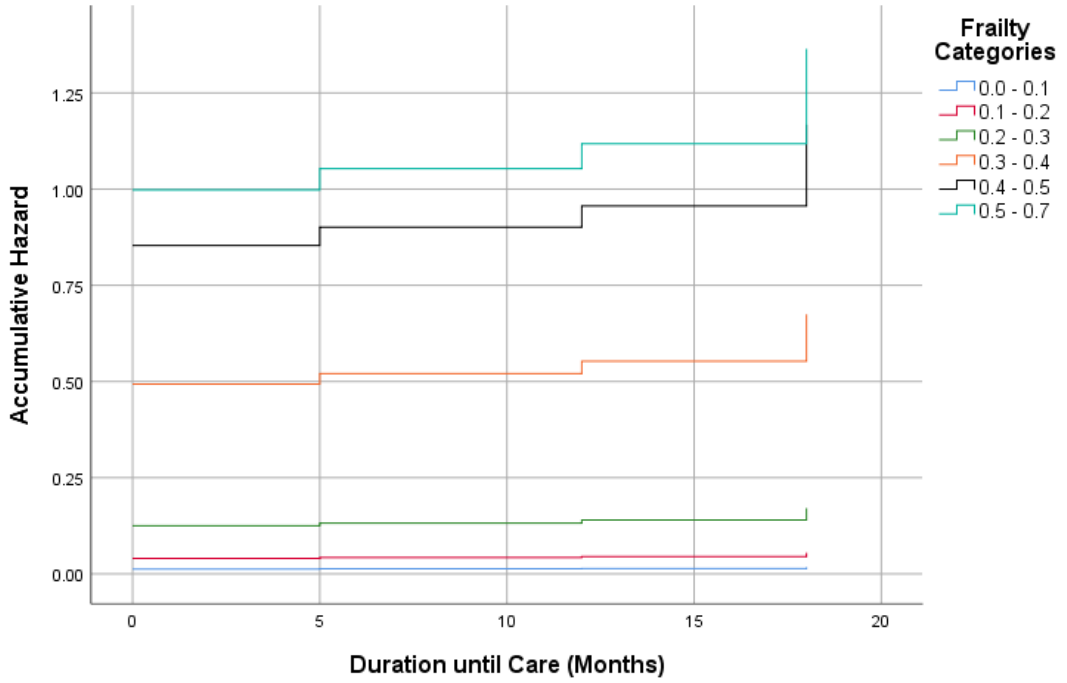


Figure 6: *A Hazard Curve Displaying the change in Risk of Needing Care over a 2-year Period.*

The hazard curves displayed in Figure 7 show a steady increase in the risk of having a fall over a 2-year period from participants in the lowest gradient up to frailty scores of 0.4, with a notable increase in risk between the gradients 0.1 to 0.2 and 0.2 to 0.3 (when participant frailty categorisation changes from pre-frail to frail). Following this there is a steep increase in the risk of having a fall, with many participants with a frailty score beyond 0.4 already having a fall at baseline assessment.

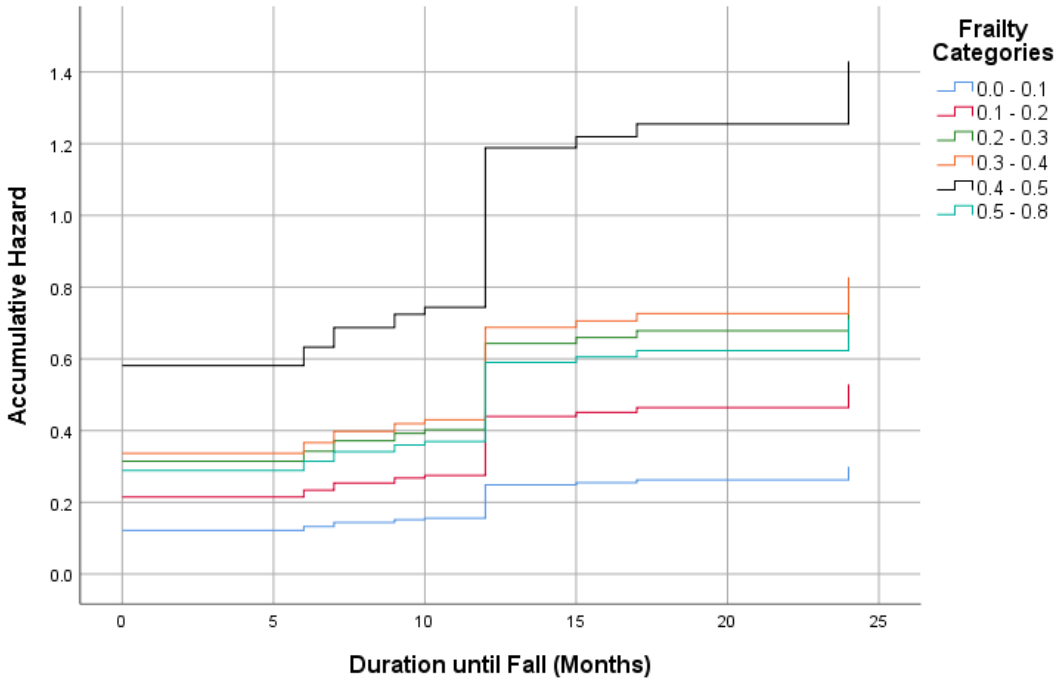


Figure 7: *A Hazard Curve Displaying the Risk of Having a fall over a 2-year Period.*

Figure 8 shows a steady increase in the risk of being hospitalised over a 2-year period. There is, however, a notable jump in risk between the gradients of 0.1 to 0.2 and 0.2 to 0.3, when participant categorisation changes from pre-frail to frail. This can be attributed to deterioration in physiological capabilities which are likely to increase the risk of injury and/or illness which would result in hospitalisation. A significant increase in risk of being hospitalised is also observed in participants possessing a frailty score of 0.4 and above, with many having already been hospitalised at their baseline assessment.

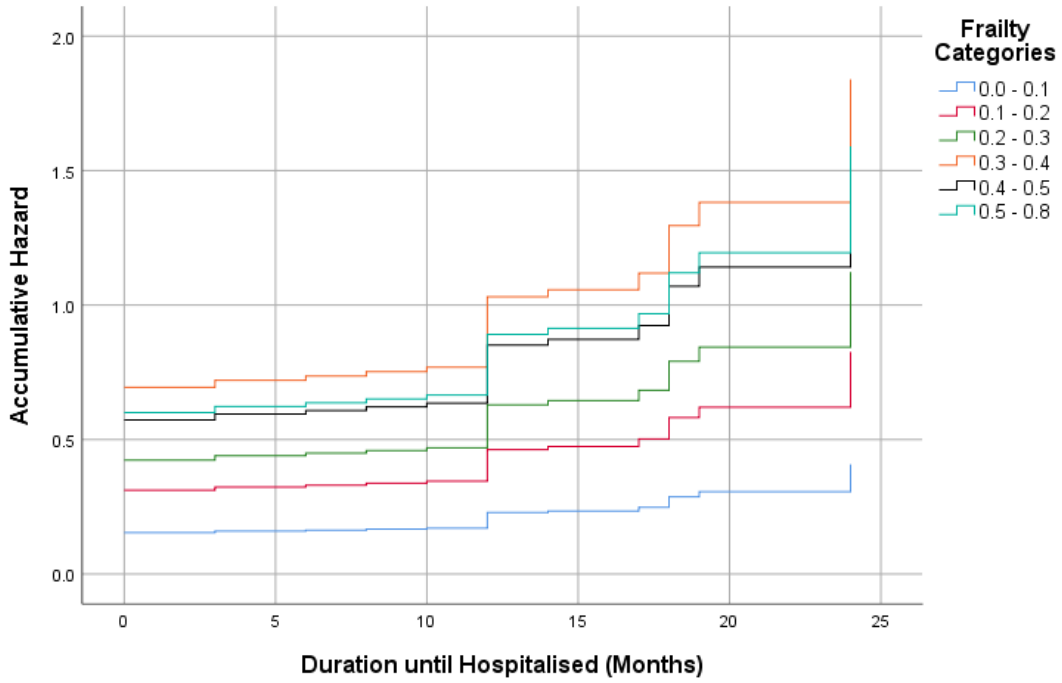


Figure 8: *A Hazard Curve Displaying the Change in Risk of being Unexpectedly Hospitalised over a 2-year Period.*

2.20.10. Sensitivity and Specificity Assessment

To assess the sensitivity and specificity (see Study 1 Data Analysis) of the FI36 in predicting prognostic outcomes Receiver Operating Characteristics (ROC) curves were utilised, results are displayed below in Table 15.

Table 15: *A Table Displaying Results from ROC Curve Analyses in Relation to Frailty (36-item) Predicting Risk of Needing Care, Hospitalisation, falls, and Death.*

	Area	Sensitivity	Specificity	Std. Error	Sig	95% CI	
						Lower	Upper
Need Care	.900	.860	.871	.028	<.001	.845	.955
Hospitalisation	.693	.701	.590	.031	<.001	.632	.753
Falls	.633	.600	.609	.032	<.001	.570	.697
Death	.795	.765	.677	.044	<.001	.710	.881

The ‘area’ score gained from the ROC curves indicate the FI36 can suitably predict the outcomes assessed. This is supported by sensitivity and specificity scores indicating a true positive and true negative outcome is likely.

2.20.11. Comparing the Predictive Capabilities of the FI36 against the FI52 and other Indices.

The prognostic capabilities of the FI36 were compared to the FI52 using Cox’s Regression analyses to ensure that no significant loss was observed as part of the variable reduction process. In addition, the CSHA Frailty Index, FP, GFI, TFI, eFI, and EFS were also re-created (see Study 1 Data Analysis Table 2 for details on each index and the necessary adjustments) as comparison tools to determine the quality of the FI36 against other indices. Each frailty index was used as a predictor in multiple Cox Regressions in relation to predicting the need for formal care, having a fall, being unexpectedly hospitalised, and death over a 2-year period. The CSHA Frailty Index was not used as a comparison tool for predicting falls as the model uses falls as a predictor of frailty as opposed to an outcome.

Comparisons of Hazard Ratios (i.e. the risk of the event occurring) were made with the most robust participants and the frailest participants. The robust participants were used as the comparison group. The scoring system of each index was used to determine which participants were considered robust/frail for each analysis. This resulted in a variation between the numbers of participants used in the Cox Regressions for each frailty model.

A total of 351 participants were used in analyses. However, some missing data was present (as discussed in Study 1 Prognostic Validity) and therefore the amount of participants used in each Cox Regression between outcomes varied. Of the 351 participants used in analyses, 46 received formal care, 106 had a fall, 85 had been hospitalised, and 20 died. Results are displayed in Table 16.

Table 16: *Comparing Hazard Ratio Risk Factors between the most Robust and Frailty Participants across Multiple Frailty Indices.*

	Frailty Indices	Robust/ Frail Participants	(Exp(B))	*p*	95% CI Lower	95% CI Upper
Formal Care	**FI52**	69/76	38.895	<.001	5.324	284.163
	FI36	95/80	20.666	<.001	4.955	86.198
	FP	54/82	3.638	.008	1.395	9.490
	GFI	19/143	---	---	---	---
	TFI	242/66	3.126	<.001	1.701	5.744
	Edmonton	244/18	7.916	<.001	3.495	17.929
	eFI	239/79	9.784	<.001	5.902	33.913
	CSHA	173/33	7.585	<.001	3.962	14.520
Hospitalisation	**FI52**	69/76	4.085	<.001	2.018	8.269
	FI36	96/80	4.693	<.001	2.389	9.220
	FP	53/82	1.603	.158	.832	3.088
	GFI	20/143	3.055	.137	.702	13.289
	TFI	241/66	1.965	.004	1.246	3.099
	Edmonton	243/17	3.286	.133	.696	15.507
	eFI	173/33	3.856	<.001	2.220	6.698
	CSHA	238/79	2.148	.001	1.390	3.318
Falls	**FI52**	74/86	3.261	<.001	1.695	6.275
	FI36	103/88	3.092	<.001	1.741	5.491
	FP	62/86	1.616	.135	.861	3.033
	GFI	21/153	1.579	.359	.595	4.191
	TFI	257/67	1.979	.001	1.305	3.002
	Edmonton	262/19	1.539	.277	.708	3.345
	eFI	193/33	3.217	<.001	1.855	5.580
Death	**FI52**	74/86	---	---	---	---
	FI36	103/88	---	---	---	---
	FP	61/86	4.394	.169	.533	36.188
	GFI	21/154	---	---	---	---
	TFI	257/67	.299	.247	.039	2.308
	Edmonton	262/18	3.286	.133	.696	15.507
	eFI	191/34	1.070	.951	.125	9.169
	CSHA	259/86	1.111	.857	.353	3.491

***** *'---' = 'no prognostic capabilities observed.*

Across the four prognostic outcomes, the revised Frailty Index (both 52-item and 36-item models), the electronic Frailty Index, and the Tilburg Frailty Indicator displayed the greatest prognostic capabilities as they predicted the need for formal care, risk of being hospitalised,

and risk of having a fall. The CSHA Frailty Index predicted two outcomes (but was only assessed against three), formal care and hospitalisation. Both the Edmonton Frail Scale and Frailty Phenotype only predicted one outcome (the need for care). Finally, the Groningen Frailty Index was the poorest performing index as it did not predict any outcome.

None of the models were able to significantly predict the risk of death over a 2-year period, further highlighting the suggestion from Study 1 that the sample was not suited to assess this outcome adequately.

Comparing the capabilities of the FI52 and FI36 shows that the variable reduction process did not reduce the prognostic capabilities of the index.

2.21. Discussion

The purpose of this study was to reduce the number of variables utilised in the FI52 to make it more time efficient, and to compare the prognostic capabilities of the shortened Frailty Index to the original model and other tools to assess the quality of the FI against other indices.

The variable reduction process reduced the number of variables within the frailty index to 35, lower than the 40 considered a minimum for ensuring reliability and validity of an accumulation deficits model of frailty (Rockwood *et al.*, 2006; Rockwood, & Mitnitski, 2007), yet validity and reliability was maintained. This indicates the variable reduction process was effective in identifying variables that either did not significantly and uniquely contribute to the model as a whole, or significantly overlapped with other variables. This shows that it is possible to maintain validity and reliability despite reducing a frailty index below the 40 variable mark. However, the compromise to this is that each variable significantly contributes to the model, and therefore places a greater emphasis on minimising missing data.

The quality comparison assessment, in which the prognostic capabilities of the FI36 were compared against the FI52 and additional models showed that the FI36 possessed either superior or equal capabilities to the FI52 (with the exception of predicting care, which was still significantly higher than all other indices) in relation to predicting all outcomes. Furthermore, as highlighted in Study 1, the lack of prognostic capabilities of the FI52 in predicting death was an issue in confirming the validity of the model. However, this assessments shows that no model was able to predict death, substantiating conclusions in Study 1 that the sample was not suitable for this assessment as opposed to any inadequacies within the revised version of Holland's (2015) Frailty Index.

2.22. Limitations

The sample was not suitable for assessing the prognostic capabilities of the Frailty Index in predicting death. While mitigating circumstances have been identified, the ability to predict death remains a key component of validation (Rockwood *et al.,* 2005), which remains unconfirmed in the shortened version of the revised Frailty Index.

The comparison of indices predicting risk of outcomes provided evidence favouring the FI36 as the index to use in this thesis. However, the indices were reconstructed and, in some cases, used proxy variables (i.e. using objective assessment as opposed to the self-rated item(s) used in the indices) such as using the ACE-III to consider the risk of cognitive impairment as opposed to a medical diagnosis of cognitive impairment) in devising frailty scores (see Table 4 in Study 1). This means that scores derived from the reconstructed indices may not accurate reflect scores that would be gained if the indices were used in their entirety and without proxy assessments.

The FI36, whilst being more time efficient than its predecessor, still remains a reductionist model as it only considers physiological and psychological markers in determining frailty severity, and therefore requires further development towards a holistic frailty tool.

2.23. Conclusions

The item reduction procedure was able to reduce the number of markers assessed in the Frailty Index to 36, with 16 items removed, without significantly compromising the reliability or validity of the model and thereby, simultaneously improving the time efficiency of completing the assessment, but also potentially identifying key physical and psychological markers in the process. However, this also places a greater emphasis on ensuring that it is only the key markers that are incorporated into the model. That is, each new variable added into the FI36 should uniquely contribute to the index, as well as the model's predictive capabilities.

2.24. Study 3: Incorporating Loneliness and Environmental Age-Friendliness into the Frailty Tool

2.25. Introduction

There has been a developing consensus that frailty should be conceptualised as more than a physiological construct (Escourrou *et al.,* 2017), but little evidence of this occurring. Lally and Crome (2007) theorise this is due to the tangible nature of physiological markers, that they can be identified and subsequently treated more readily compared to non-physical markers. Yet tangibility should not be used as a parameter for determining importance, although it is accepted that tangibility does help identify frailty markers. Indeed this has shown to be the case when attempting to identify psychosocial frailty markers, with research marred with inconsistency as to how to define psychosocial frailty and what the key markers of this dimension are. These issues are also present in environmental frailty research, and although it was previously noted that there is also no suitable environmental assessment tool to analyse the environment on an individual basis, and therefore suitable for frailty assessment, that has since been addressed (Garner & Holland, 2019). Despite this, the variables 'loneliness' and 'age-friendly environments' were identified as potential candidates to represent these frailty dimensions within the FI36. However, as discussed in Study 2, Rockwood's (2005) variable inclusion criteria is no longer sufficient as each item within a smaller accumulation of deficits model should uniquely contribute to the overall model in terms of predicting outcomes to justifiably be incorporated into the model. Therefore the aim of the current study is to assess the relationship between loneliness, age-friendly environments, and frailty to determine if these items can justifiably be incorporated into the FI36.

2.26. Aims

1. Assess if the new candidate items (Loneliness and Age-Friendly Environment (AFE)) can be incorporated into the FI36.
2. If candidate items are included (making it a 38-item frailty index (FI38)), perform a quality comparison between the would-be FI38 against its previous versions (the FI52 and FI36) and against multiple other indices.

2.27. Methods

2.28. Participants

A total of 162 participants (66 male, 96 female, aged 58-96) completed a frailty assessment and loneliness questionnaire, and of those 162 participants, 121 participants (52 male, 69 female, and aged 58-96) also completed an assessment of their perception of the environmental age-friendliness of their home and local community.

2.29. Ethics

An ethics amendment to the ethical consent given for Studies One and Two was given a favourable opinion for the Age-Friendly Environment Assessment Tool (AFEAT, Garner & Holland, 2019) to be included in assessment criteria for the study 'Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and The ExtraCare Charitable Trust – follow-up'.

2.30. Procedure

The procedure followed for this study was the same as Studies 1 and 2.

2.31. Measures

2.31.1. Age-Friendly Environment Assessment Tool

The Age-Friendly Environment Assessment Tool (AFEAT) is a 10-item scale designed to assess the age-friendliness of the environment from the older person's perspective (Garner, & Holland, 2019). The AFEAT was developed to represent the 8 dimensions of the World Health Organization's (2007) age-friendly environments checklist. Scores range from 10 to 50, with higher scores indicative of higher perceptions of environmental age-friendliness.

2.31.2. Brief UCLA Loneliness Scale

This assessment of loneliness is a short 4-item scale in which participants consider the deepness and strength of their social ties with friends and family (Russell, Peplau, & Cutrona, 1980). Scores range from 3-12, with higher scores indicative of lower feelings of loneliness.

The measures used in this study to assess frailty and outcomes (such as needing care, hospitalisation, having a fall etc.) are the same as those used in Studies 1 and 2.

2.32. Data Analysis

2.32.1. Incorporating Candidate Items into the FI36

In a similar manner to the candidate items reviewed in Study 1, Pearson's correlation was used to determine if loneliness and AFE are significantly related to frailty, and therefore meet Rockwood's (2005) criteria for variable inclusion. However, as noted in Study 2, having fewer items in the FI places a greater importance on ensuring that any variables included also

uniquely contribute to the model. Therefore, a series of hierarchical regressions will be performed, in which frailty will be controlled for, to assess if loneliness and AFE significantly predict any of QoL, the amount of hourly care an individual receives on a weekly basis, and the number of falls an individual suffers. These outcomes were chosen as the FI36 significantly predicts these outcomes, see Study 2. In this scenario, Rockwood's (2005) variable inclusion criteria and those set in Study 2 would be met, and therefore the variables loneliness and AFE could be incorporated into the FI36 to make it a 38-item holistic model.

2.32.2. Quality Comparison Assessment

If the candidate items are justified in their inclusion, another quality comparison assessment will be performed to compare the new holistic Frailty Index (FI38) against previous models (FI52 and FI36) and the six indices used in the quality comparison assessment used in Study 2 (the Frailty Phenotype, Accumulation of Deficits, Groningen Frailty Index, Tilburg Frailty Indicator, electronic Frailty Index, and the Edmonton Frail Scale, see the Data Analysis section in Study 2 for more details on the different indices). However, unlike Study 2, there is no longitudinal data available, and therefore a comparison using Cox Regressions is not available. Therefore odds ratios and a sensitivity and specificity comparison of sensitivity and specificity will be the comparison analyses.

2.33. Results

2.33.1. Descriptive Statistics

The mean, standard deviation, and range of scores for the variables AFEAT, loneliness, quality of life, frailty, and care are presented below in Table 17.

Table 17: *A Table Displaying the Mean, Standard Deviation, and Range of Scores for the Variables Age-Friendly Environments, Loneliness, and Frailty.*

	n	**Mean**	**Std. Dev**	**Range**
Age-Friendly Environment (AFEAT)	121	41.79	6.226	21 - 50
Loneliness	162	10.72	1.673	4 - 12
Frailty (36-item)	161	.141	.130	0 - .638
Quality of Life	159	37.94	6.926	6 - 48
Formal Care Received (Hours/week)	162	.985	6.170	0 - 74
Number of Falls (previous 12 months)	141	.59	2.094	0 - 20

2.33.2. Candidate Item Correlation Assessment

A Correlation analysis was performed to assess if loneliness and AFEAT is significantly correlated with frailty, as this is a requirement set by Rockwood and Mitnitski (2006) for incorporating variables in an accumulation of deficits model of frailty assessment.

A significant negative correlation was discovered between frailty and loneliness ($r = -.227$, $p=.004$) and frailty and age-friendly environments ($r = -.230$, $p=.025$), indicating that higher levels of frailty are associated with increased feelings of loneliness and lower perception of age-friendly environments. These findings indicate that both loneliness and AFEAT can theoretically be incorporated into the FI36.

2.33.3. Candidate Item Hierarchical Regressions Controlling for Frailty

A series of hierarchical regressions were performed to assess if both loneliness and age-friendly environment significantly predict frailty outcomes whilst controlling for frailty, as such conclusions would indicate that including both measures into the FI36 would significantly improve the predictive validity of the index, subsequently justifying their inclusion. Results are displayed below in Table 18.

Table 18: *A Table Displaying the Predictive Capabilities of Loneliness and AFE whilst Controlling for Frailty.*

		n	R^2 Change	F	Std. Beta	Sig.	95% Confidence Interval	
							Lower	Upper
Loneliness	**Frailty**	159	.339	79.575	-.582	<.001	-39.557	-25.214
	Quality of Life	159	.091	24.649	.313	<.001	.799	1.854
	Frailty	161	.097	16.820	.311	<.001	7.804	22.306
	Formal Care Hours	161	.001	.230	.038	.632	-.443	.727
	Frailty	141	.256	47.102	.506	<.001	6.830	12.351
	Number of Falls	141	.010	1.852	.104	.176	-.061	.329
Age-Friendly Environment	**Frailty**	117	.345	60.127	-.588	<.001	-40.131	-23.798
	Quality of Life	117	.025	4.508	.168	.036	.013	.380
	Frailty	120	.129	17.328	.359	<.001	9.691	27.282
	Formal Care Hours	120	.032	4.483	.189	.036	.014	.422
	Frailty	99	.268	35.112	.517	<.001	7.131	14.315
	Number of Falls	99	.006	.726	-.081	.396	-.107	.043

** 'Frailty' represents Model 1 of the hierarchical regressions, and the 'Outcomes' Model 2.*

Results from the hierarchical regressions indicate that incorporating loneliness into the FI36 would improve the predictive capability of the model in predicting quality of life. Additionally, adding in AFE would improve the ability of the model to predict formal care hours. These findings justify the inclusion of loneliness and age-friendly environments into the FI36, to make it a 38-item model (FI38). To determine the scoring system for the variables a frequencies analysis to gain score percentiles was used. The scoring systems are presented below in Table 19.

Table 19: *Scoring Systems for the variables Loneliness and Age-Friendly Environments.*

Loneliness	Age-Friendly Environments
$\leq 8 = 1$	$< 38 = 1$
9 = 0.66	38 - 40 = 0.75
10 - 11 = 0.33	41 - 43 = 0.50
12 = 0	44 - 46 = 0.25
	$\geq 47 = 0$

2.33.4. Quality Comparison Assessment

In Study 2 the FI36 prognostic capabilities were compared against the FI52 and multiple other indices. This was done to directly assess the prognostic qualities of the FI36 to ensure that no capabilities were lost as part of the variable reduction process, and to assess how well the tool predicts outcomes compared to other indices.

Whilst a similar approach would be ideal for the FI38, there was no longitudinal data available to assess these capabilities. Therefore a comparison between indices using Odds Ratios, as well as a sensitivity and specificity comparison (similar to that conducted by Drubbel *et al.,* 2014) was conducted.

The odds ratio analyses were a comparison of risk between the most robust vs. frailest participants, with the most robust participants considered as the comparison group. The likelihood of an outcome occurring is represented by the 'odds ratio' score. The higher the odds ratio score, the more likely the event will happen in the frailest participants compared to the most robust participants. For example, a hospitalisation odds ratio score of 2.0 will suggest that the frailest condition is twice as likely to be hospitalised compared to the most robust group.

Due to a small sample size, in some instances the sample size was too small to provide a meaningful comparison and therefore a different frailty severity was used in the analysis, which is bracketed and described using the scoring systems of the respective frailty tool used in the analysis.

From the 156 participants who were utilised in this comparison assessment, 12 received formal care, 31 had a fall, and 26 had been hospitalised unexpectedly. However, as only 2 participants had died no assessment in predicting mortality was completed. Results of the sensitivity and specificity and odds ratios comparisons are displayed below in Tables 20 and 21.

For two analyses, odds ratios were not possible (these are represented by a '---' in Table 18). This is because in both analyses the robust condition had no participants in which the event had occurred (i.e. a robust participant who received care or had been hospitalised) and therefore no comparison could be made. Yet where a comparison of the Frailty Index models and other indices was possible, each Frailty Index version provided a greater odds ratio risk of outcomes compared to the comparison frailty tools.

Examination of the sensitivity and specificity comparison output displays similar specificity and sensitivity scores for the FI38 compared to the FI36 and FI52, across all outcomes. Additionally, compared to other indices, the FI38 possesses similar equal, and in some cases greater, sensitivity and specificity in predicting the outcomes assessed. This would indicate that the FI38 is equally as good as both previous models and other indices in predicting outcomes whilst providing further strides towards the development of a holistic frailty assessment.

Table 20: *Odds Ratio Comparison between Multiple Frailty Indices.*

		Participant Frailty State (Not Frail/ Frail)	Odds Ratio	95% Confidence Interval Lower	Upper
Formal Care	**FI52**	42/31	---	---	---
	FI36	69/25	53.429	6.372	447.977
	FI38	61/26	44.000	5.261	367.990
	FP	30/13	1.083	.926	1.267
	GFI	23 (slight frailty)/40	8.345	1.001	69.557
	TFI	106/49	13.333	2.796	63.587
	Edmon	117/19 (vulnerable frailty state)	7.533	1.703	33.322
	CSHA	116/38 (pre-frail)	83.636	10.542	663.551
Hospitalisation	**FI52**	42/31	49.786	6.060	409.032
	FI36	70/17	19.556	5.330	71.748
	FI38	61/26	---	---	---
	FP	30/13	4.20	.610	28.918
	GFI	22 (slight frailty)/39	6.250	1.274	30.657
	TFI	106/49	5.726	2.325	14.102
	Edmon	117/19 (vulnerable frailty state)	13.333	4.314	41.211
	eFI	80/68	2.333	.914	5.959
	CSHA	117/38 (pre-frail)	7.782	3.121	19.403
Falls	**FI52**	39/21	50.667	5.811	441.772
	FI36	64/16	17.171	3.953	58.230
	FI38	57/17	14.906	3.702	60.013
	FP	26/12	3.833	.701	20.971
	GFI	21 (slight frailty)/35	3.683	.986	13.765
	TFI	94/40	4.244	1.813	9.840
	Edmon	106/12 (vulnerable frailty state)	1.804	.499	6.529
	eFI	75/55	3.870	1.588	9.434

***** *'---' requirements for analysis not met.*

Table 21: *Area under the Curve, Sensitivity and Specificity Comparison between Multiple Frailty Indices.*

		Participants	AUC	Sensitivity/ Specificity	*p*	95% Confidence Interval	
						Lower	Upper
Formal Care	**FI52**	156	.913	.827/.739	<.001	.836	.990
	FI36	155	.906	.857/851	<.001	.830	.982
	FI38	156	.878	.857/.852	<.001	.772	.983
	FP	155	.712	.615/.852	.012	.535	.889
	GFI	153	.786	.786/.570	.006	.618	.824
	TFI	154	.618	.462/.775	.159	.448	.788
	Edmon	151	.734	.571/.894	.004	.573	.896
	eFI	152	.811	.917/.549	<.001	.685	.937
	CSHA	156	.870	.917/.824	<.001	.771	.969
Hospitalisation	**FI52**	154	.729	.712/.660	<.001	.643	.815
	FI36	155	.764	.759/.763	<.001	.681	.847
	FI38	156	.743	.729/.639	<.001	.659	.827
	FP	155	.534	.241/.845	.482	.438	.630
	GFI	153	.598	.593/.619	.041	.504	.691
	TFI	154	.607	.379/.835	.026	.513	.702
	Edmon	151	.629	.305/.948	.007	.534	.723
	eFI	152	.703	.690/.635	<.001	.616	.791
	CSHA	156	.603	.362/.844	.033	.508	.698
Falls	**FI52**	156	.631	.673/.589	.009	.540	.722
	FI36	155	.666	.667/.626	.001	.579	.753
	FI38	156	.670	.714/.571	.001	.580	.759
	FP	155	.484	.385/.583	.744	.385	.583
	GFI	153	.596	.776/.430	.054	.501	.692
	TFI	154	.559	.327/.792	.234	.460	.659
	Edmon	151	.510	.163/.860	.843	.412	.608
	eFI	152	.633	.653/.590	.008	.538	.729

2.34. Discussion

The purpose of this study was to assess the unique contributions of loneliness and age-friendly environments to determine if both markers should be considered key markers of the psychosocial and environmental frailty dimensions, and subsequently be incorporated into the FI36 to make a holistic frailty tool.

Analyses highlighted the importance of understanding the age-friendliness of the environment from the individual perspective in relation to frailty. This justifies the use of the AFEAT as the tool used to assess the environmental influences on frailty progression compared to a broader assessment tool that is oriented towards community-level assessment.

Loneliness was previously identified as one of the few unambiguous psychosocial frailty markers and is already used in frailty assessment in other indices. Yet the unique contribution of loneliness as part of the psychosocial dimension was not known. The findings indicated that loneliness should be considered a key psychosocial frailty markers, and whilst its incorporation into the FI36 is not wholly represent the psychosocial frailty dimension, it does offer a promising starting point.

The inclusion of age-friendly environments and loneliness into the FI36 to make it a holistic 38-item index (FI38) were considered to be fully justified as analyses indicated these changes would improve the explainable variance attributed to the now FI38 in relation to predicting quality of life and formal care. This means that both loneliness and perceptions of environmental age-friendliness met requirements set in Study 2 for variable inclusion.

The quality comparison analyses also reflected favourably on the FI38 and previous versions, with all versions of the Frailty Index possessing higher odds ratio scores (indicative of risk factor) compared to all other indices for the outcomes assessing the need for care and having a fall. The FI38, however, could not be used as part of the odds ratios assessment for the outcome of being hospitalised, the previous versions of the model possessed higher odds ratio scores than all other indices. Furthermore, the FI38 also possessed higher area under the curve, and sensitivity and specificity scores for all outcomes compared to other indices. Scores did, however, vary compared to the previous versions of the frailty index (FI52 and FI36), but this variation was minimal. These findings suggest that incorporating assessments of loneliness and perceptions of environmental age-friendliness into the FI36, making it a 38-

item model, did not have a detrimental impact on the predictive capabilities of the model. Therefore, with four dimensions of frailty (physiological, psychological, psychosocial, and environmental frailty) represented in the FI38, the tool is ready to examine the relationship between frailty and psychological resilience.

2.35. Limitations

The aim of the odds ratio was to compare the most robust participants against the frailest using the scoring systems of each index assessed. Following this procedure produced varying numbers of participants for each frailty index. Furthermore, in some cases there were most robust participants were considered pre-frail (such as in the Groningen Frailty Index) as opposed to being categorised as robust, and in other indices (such as the Edmonton Frail Scale, and CSHA Frailty Index) the frailest participants in the analyses were considered pre-frail as opposed to frail.

With the inclusion of loneliness and perceptions of environmental age-friendliness the FI38 has provided initial steps towards the coveted holistic frailty tool. However, both dimensions (psychosocial and environmental frailty dimensions) are still largely under-represented within the index, and therefore further inclusions of markers (once identified) to represent these dimensions is warranted to address this imbalance.

2.36. Conclusion

The purpose of this study was to develop the FI36 towards a holistic tool with the inclusion of a psychosocial and environmental frailty marker, and whilst the index should not be considered complete due to the potential to include further psychosocial and environmental frailty markers (once identified), it is developed sufficiently to allow for a holistic assessment of frailty to be conducted, allowing for a thorough analysis of the relationship between frailty and psychological resilience.

Chapter 3

The Resilience - Frailty Paradigm

3.1. Chapter Aims

In Chapter 1 it was concluded that, in the context of frailty, greater awareness towards the response mechanism component of resilience was required (Cosco *et al.*, 2017), as well as the role of psychological factors in building and maintaining resilience. Building on this, Holland *et al* (2018) theorised that in the presence of frailty, when the ability to physiologically adapt to stressors is compromised, that psychological facets of resilience adopt a more prominent role in the improvement and maintaining of resilience i.e. being resilient despite frailty. However, Holland *et al* (2018) also argued the need for further research into this phenomenon, including what benefits may be gained by building psychological resilience.

Yet, in the event that benefits can be identified, and therefore justify the building of psychological resilience, we currently lack a definitive pathway for implementing such improvements. This is largely due to research examining the frailty-resilience relationship remaining theoretical, with little (if any) attempts to identify the key resilience traits in frail older adults (MacLeod *et al.*, 2016). This means that in the event we confirm that high psychological resilience is beneficial to older adults, we lack an intervention template to help build resilience (MacLeod *et al.*, 2016). Therefore a newly designed intervention is at greater risk of poor feasibility (Kelly *et al.*, 2018), and failure to instigate the desired change, or a lack of reproducibility (Goodyear-Smith *et al.*, 2015).

Therefore, the aim of Chapter 3 was to identify what the benefits associated with high psychological resilience are in the context of frailty, and if justified, consider and implement a method of developing a resilience-building intervention whilst mitigating the risks of poor feasibility and ineffective procedures.

3.2. Study 4: Psychological Resilience and Frailty

3.3. Introduction

Current evidence on the benefits of maintaining high levels of psychological resilience despite the presence of frailty is minimal. Under Cosco *et al's* (2017) definition (that resilience is both a preventative measure and response mechanism, and is characterised by functioning beyond what would be expected based on frailty severity), which is how we define resilience for this research, an increased level of functioning (Cosco *et al.,* 2017) and higher quality of life (Holland *et al.,* 2018), is expected in frail older adults who maintain high resilience. However, both prospects require further supportive evidence.

A review of resilience research in older adults was conducted by MacLeod *et al* (2016), in which the top performing resilience scales were identified and the benefits of high resilience evaluated. From the 15 resilience scales assessed, three were identified as having the best psychometric and measurement qualities: the Brief Resilience Scale (Smith *et al.,* 2008), the Connor-Davidson Resilience Scale (Connor & Davidson, 2003), and the Resilience Scale for Adults (Friborg, Hjemdal, Rosenvinge, & Martinussen, 2006). Several benefits associated with high resilience were also identified such as higher quality of life, greater mental health and well-being, reduced loneliness, reduced depressive symptomology and reduced mortality risk (Cacioppo, Reis, & Zautra, 2011; Christenson, & Neumark-Sztainer, 2007; Gerino, Rolle, Sechi, & Brustia, 2003; Hall-Lande, Eisenberg, Christenson, & Neumark-Sztainer, 2007; Kim, Lim, Kim, & Park, 2018; Laird, Krause, Funes, & Lavretsky, 2019; Wermelinger, Lucchetti, & Lucchetti, 2017). These findings by MacLeod *et al* (2016) are especially important as they are also outcomes of frailty (Gale *et al.,* 2018; Mhaolian *et al.,* 2012). Although, despite focusing on resilience in older adults, frailty was not considered as a potential factor that may impact on the improvements outlined. Therefore we remain uncertain as to if similar benefits would be observed in frail older adults when building resilience.

We must also consider the effect of high resilience directly on frailty. For instance, Rockwood and Mitnitski (2015) argue that resilience is the polar opposite of frailty, and whilst we argue against this reductionist perspective (as discussed in Chapter 1), it was not concluded that this theory is without merit. Under this conceptualisation building resilience would subsequently reduce frailty, to which we postulate would be achieved by improving markers evaluated in frailty assessment. Although, Rockwood and Mitnitski's (2015) conceptualisation is based on physiological resilience, if accurate, it is reasonable to consider a similar impact on frailty from a psychological perspective.

Therefore, the purpose of this study was to determine the impact of resilience on frailty directly, and assess the validity of the potential benefits to possessing high resilience when frailty is considered.

3.4. Aims

1. Assess if psychological resilience significantly predicts frailty markers.
2. Assess if psychological resilience predicts outcomes (see below) when controlling for frailty.
3. Assess if psychological resilience moderates the predictive strength of frailty in predicting outcomes (see below).

The outcomes being assessed are quality of life (based on Holland *et al's* (2018) assertions), perceptions of functional independence (based on Cosco *et al's* (2017) definition of resilience in the context of frailty), anxiety and depressive symptomology, and loneliness (based on MacLeod *et al's* (2016) findings), and the amount of formal care received on a weekly basis.

3.5. Methods

3.6. Participants

A total of 119 participants (50 male, 69 female, and aged 59-96) were recruited from ExtraCare Retirement Villages and local communities in the West Midlands of the UK as part of the larger study 'Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and The ExtraCare Charitable Trust – a follow-up.'

3.7. Ethics

An ethics amendment was accepted by Aston University Life & Health Sciences Ethics Committee to incorporate the Connor-Davidson Resilience Scale 10-item (CD-RISC10) (Connor & Davidson, 2003) into the study 'Collaborative Research between Aston Research Centre for Healthy Ageing (ARCHA) and The ExtraCare Charitable Trust – a follow-up'.

3.8. Measures

3.8.1. Frailty Index 38-item

The Frailty Index 38 (see Chapter 2: Study 3) was used to assess frailty using a holistic approach.

3.8.2. Connor-Davidson Resilience Scale 10-item

The Connor-Davidson Resilience Scale 10-item (CD-RISC10) is a self-reported measure derived from the Connor Davidson Resilience Scale 25-item (Campbell-Sills & Stein, 2007). The scale has been validated in worldwide cohorts across 13 studies, including older adults (Davidson, 2018). The CD-RISC10 scoring system ranges from 0 to 40, with higher scores

indicative of greater psychological resilience. Across this spectrum, older adults living in Western society produce an average score of 32.0 (Davidson, 2018).

3.8.3. Outcome assessments

The measures used to assess quality of life (CASP12), anxiety and depressive symptomology (HADS), perceptions of functional independence (FLP), the amount of formal care received on a weekly basis, number of falls, and number of times hospitalised are the same as those used in Studies 1 and 2.

3.9. Procedure

After informed consent was gained, participants completed the Frailty Index assessments, the CD-RISC10 scale, and the outcome assessments.

3.10. Data Analysis

3.10.1. Resilience Predicting Frailty Markers

To assess if resilience has a direct impact on frailty (based on Rockwood and Mitnitski's (2015) theory), a series of linear regressions will be performed to assess if resilience predicts frailty markers used in the FI38.

3.10.2. Predictive Capabilities of Resilience whilst Controlling for Frailty

A series of hierarchical regressions will be performed to assess the predictive strength of resilience in relation to predicting the outcomes outlined above whilst controlling for frailty. Significant results would suggest that, without needing to reduce frailty severity, improvements to outcomes could be achieved by building psychological resilience.

3.10.3. Assessing the Moderating Effect of Resilience on Frailty Predicting Outcomes

To assess if psychological resilience would reduce the negative impact of frailty on outcomes, a series of Hayes (2017) bootstrapping moderation analyses were performed.

Data analysis was conducted using Statistical Package for Social Sciences (SPSS 25) and mediation/moderation analysis used the macro PROCESS (Hayes, 2017).

3.11. Results

3.11.1. Descriptive Statistics

Two tables of descriptive statistics are presented. The first table (Table 22) will present the mean standard deviation and range of scores for measures used in the 38-item Frailty Index (instrumental activities of daily living, activities of daily living, perceived health, grip strength, walking speed, sit-to-stand speed, loneliness, perceptions of environmental age-friendliness, feelings of exhaustion, and cognitive assessments of attention and fluency). The second table (Table 23) will present the mean, standard deviation, interquartile range and range of scores for the variables resilience, frailty, quality of life, anxiety and depressive symptomology, functional limitations, amount of care received on a weekly basis (total hours/week), falls, and hospitalisation. Results are presented below.

Table 22: *Descriptive Statistics of Measures used to assess Frailty*

	n	*Mean*	*Std. Deviation*	*Range*
Perceived Health	119	3.29	1.226	1 - 5
Loneliness	118	10.67	1.774	4 - 12
Age-Friendly Environment	119	41.92	6.173	21 - 50
Instrumental Activities of Daily Living	119	7.28	1.578	1 - 8
Activities of Daily Living	119	5.55	1.162	0 - 8
Attention	116	17.02	1.216	13 - 18
Fluency	116	11.53	2.305	2 - 14
Walking Speed	103	1.15	.314	.25 - 1.67
Sit-to-Stand Speed	105	1.238	.940	.36 - 5.00
Feelings of Exhaustion	115	.21	.382	0 - 1
Grip Strength	113	25.75	9.588	8.5 - 54.3
Depressive Symptomology	117	2.29	2.457	0 - 13

Table 23: *Descriptive Statistics of Resilience, Frailty, and Outcomes***.**

	n	*Mean*	*Std. Deviation*	*Range*
Resilience	119	32.07	5.842	12 - 40
Frailty	114	.143	.123	0 - .586
CASP12	115	37.96	7.152	6 - 48
Anxiety Symptomology	117	3.35	3.038	0 - 14
Functional Limitations	108	129.29	156.710	0 - 691
Formal Care	118	1.314	7.198	0 - 74
Falls	97	.43	1.376	0 - 12
Hospitalisation	108	.444	1.774	0 - 17

3.11.2. Resilience Predicting Frailty Markers

Results of the linear regressions performed to determine if resilience predicts frailty measures used to determine frailty severity are presented below in Table 24.

Table 24: *Resilience Predicting Assessments of Frailty*

	R^2	F	df1/df2	*p*	95% Confidence Interval	
					Lower	Upper
Perceived Health	.001	.170	1/117	.681	-.030	.046
Loneliness	.084	10.585	1/116	.001	.035	.143
Age-Friendly Environment	.053	6.547	1/117	.012	.055	.431
Instrumental Activities of Daily Living	.008	.973	1/117	.326	-.025	.074
Activities of Daily Living	<.001	.038	1/117	.846	-.040	.033
Attention	.001	.138	1/114	.711	-.046	.032
Fluency	.001	.132	1/114	.717	-.087	.060
Walking Speed	.003	.261	1/101	.611	-.014	.008
Sit-to-Stand Speed	<.001	.008	1/103	.929	-.031	.034
Feelings of Exhaustion	.032	3.691	1.113	.057	-.023	.000
Grip Strength	.011	1.215	1/111	.273	-.138	.483
Depressive Symptomology	.072	8.955	1/115	.003	-.191	-.039

Results from the linear regressions show that high psychological resilience significantly predicts perceptions of environmental age-friendliness, loneliness, and depressive symptomology, and marginally predict feelings of exhaustion. This suggests that if improvements in resilience were observed, improvements in these frailty markers would also be observed.

3.11.3. Resilience Predicting Outcomes while Controlling for Frailty

Hierarchical regressions were performed to assess if resilience significantly predicted outcomes whilst controlling for frailty. Results are displayed below in Table 25.

Table 25: *Hierarchical Regressions assessing Resilience Predicting Outcomes whilst Controlling for Frailty*

		R^2 Change	F	df1/df2	*p*	Std. Beta	95% Confidence Interval	
							Lower	Upper
Model 1	**Frailty**	.322	53.222	1/112	<.001	-.568	-40.435	-23.111
Model 2	**CASP12**	.066	11.893	1/111	.001	.257	.137	.506
Model 1	**Frailty**	.035	4.154	1/114	.044	.187	.126	8.851
Model 2	**Anxiety Symptom.**	.106	13.930	1/113	<.001	-.326	-.265	-.081
Model 1	**Frailty**	.626	175.562	1/105	<.001	.791	989.138	1337.279
Model 2	**Functional Limit.**	.004	1.256	1/104	.265	.067	-1.402	5.045
Model 1	**Frailty**	.143	19.230	1/115	<.001	.378	11.561	29.895
Model 2	**Formal Care**	.012	1.549	1/114	.216	.107	-.078	.343

Results from the hierarchical regressions show that when frailty is controlled for, resilience significantly predicts quality of life and anxiety symptomology. Therefore, if there is no change in frailty, but a significant improvement to resilience, improvements to these outcomes is also expected.

3.11.4. Assessing the Moderating Effect of Resilience on Frailty

Results from the Hayes (2017) bootstrap moderation analyses did not discover any moderating effect of resilience in relation to frailty predicting quality of life, anxiety symptomology, or formal care.

3.12. Discussion

The aims of this study were to evaluate the effect of resilience on markers used to assess frailty (based on assessments completed for the FI38), and to consider the benefits of maintaining high levels of resilience despite the presence of frailty.

In considering the validity of Rockwood's assertion that resilience is the polar opposite of frailty, three frailty markers were identified that resilience significantly predicts: loneliness, depressive symptomology, and perceptions of environmental age-friendliness. Benefits to loneliness and depressive symptomology were consistent with findings by MacLeod *et al* (2016), and it can be argued that high resilience allows individuals to better utilise resources at their disposal to achieve their goals, and subsequently perceptions of environmental age-friendliness are likely to increase as their needs are being met. Yet these findings provide evidence for and against Rockwood's assertion. For instance, it can be confirmed that improving resilience will have a beneficial impact on these markers, and therefore can potentially reduce frailty. However, the markers identified are either uncommon in frailty indices (i.e. loneliness and depressive symptomology), or exclusive to the FI38 (i.e. perceptions of environmental age-friendliness), and therefore potential improvements to frailty are dependent on the markers assessed within the frailty index used to assess frailty severity. Furthermore, resilience did not predict the majority of markers assessed, and therefore any reversing of frailty severity would be minimal. Although the markers predicted by psychological resilience are non-physiological markers, and therefore it is plausible to consider that similarly physiological resilience will predict physiological frailty markers. But this remains unconfirmed. Therefore, whilst we can confirm that psychological resilience can have a beneficial impact on frailty severity, the benefits are not absolute with regards to frailty reduction, and therefore resilience should not be considered the polar opposite of frailty.

Consistent with Holland *et al's* (2018) assertions, an improvement in quality of life would be expected if resilience was improved in older adults irrespective of frailty severity. This is not

surprising as improvements in quality of life as a result of improving resilience are commonly cited across the lifespan (MacLeod *et al.*, 2016). This is important as poor quality of life is considered a fundamental problem in older adults (Baernholdt, Hinton, Yan, Rose, & Matos, 2012), and considerably more so in older adults with impairments (Dalton *et al.*, 2003; Norman, Wirth, Neubauer, Eckardt, & Stobaus, 2015). Therefore any potential pathway for improving this should be explored.

In addition to quality of life, it was also found that an improvement to anxiety and depressive symptomology should also be expected in the event resilience is improved and frailty is not. However, contradictory results were obtained when compared to Cosco's (2017) definition of resilience as no improvement in perceived functional independence was observed. One possibility could be that Cosco (2017) defined resilience as a combination of physiological and psychological components, whereas the current study focused solely on the psychological side of resilience in relation to frailty. Therefore it may be that the physiological component of resilience is oriented more towards functional independence.

3.13. Limitations

It is possible that analyses were hindered by utilising the whole Frailty 38-item index as the largest component of the model is physiological, and therefore a fairer comparison would have been to assess the impact of psychological resilience on the effects of psychological frailty.

3.14. Conclusions

These findings have shown that improving psychological resilience can have a significant benefit on a multiple outcomes in frail older adults. The confirmation of an improvement to quality of life is especially important given the significant decrease in quality of life commonly associated with frailty. Therefore it can be concluded that improving resilience in older adults would have a beneficial impact on their lives and should be pursued.

3.15. Study 5: Intervention Design: A Co-Creation and Feasibility Study.

3.16. Introduction

In Chapter 1, four candidate items were identified as potential pathways to building resilience. That is, improving one or more of these components will subsequently improve resilience. It has been confirmed that these markers are fundamental in improving resilience in a variety of contexts, and therefore it is reasonable to consider that they may also be effective in improving resilience in the context of frailty. These markers are social support, self-efficacy, optimism, and coping strategies (Southwick *et al.*, 2011). Chapter 1 reviewed these four markers, considered their interrelatedness with one another and how they improve resilience. It was concluded that to build psychological resilience in older adults, improving the effectiveness of their coping strategies should be the primary method of choice. Indeed this consideration was also supported by Benzies and Mychasiuk (2009) and Southwick *et al* (2011) who produced similar conclusion in relation to building resilience in the contexts of family, mental health, and deficit loss. Increasing the effectiveness of coping strategies is achieved in two parts: decreasing the use of maladaptive and avoidant coping strategies (such as ignoring the stressor); and increasing the likelihood that positive adaptive coping strategies (strategies that aim to directly overcome or adapt to the stressor) are implemented (Chinaveh, 2013). According to Yi-Frazier *et al* (2009) this is determined by the amount of resources[3] available to the individual, and how effectively they are used to overcome a stressor.

As this intervention will be tailored towards residents living in ExtraCare retirement villages, the amount of resources available within the village is likely to be the same amongst residents (although the majority of residents possess the capability to travel outside the village). Therefore, increasing the effectiveness of coping strategies used by participants should be

[3]A resource is something that is available to the individual that helps them overcome or adapt to a stressor. For instance, when unwell a resource to combat the illness (i.e. the stressor) would be a GP, pharmacy, and/or hospital. Alternately, when living with bereavement, social support is an important resource (Logan *et al.*, 2018).

achieved by improving the efficiency in which residents utilise the resources available to them.

The capacity to effectively use resources is dependent on how well the individual is able to ruminate about the stressor, analyse the cause of the stressor, determine what their optimal outcome is, consider what resources are available to them that may help overcome the stressor, and then effectively utilise their resources to achieve their goal. This process is referred to as problem-solving (Schwarz, & Skurnik, 2003).

In reviewing the relationship between coping strategies and problem-solving, D'Zurilla, and Nezu (1990) concluded that individuals who utilise positive adaptive coping strategies more frequently have significantly higher problem-solving skills than individuals who implement maladaptive coping strategies. According to Hoyt (2006) this is because problem-solving skills provide a structure in which individuals can define the cause of the problem (i.e. stressor) and decide the best pathway to achieve their goal, and can therefore demonstrate their strategy. Individuals with high problem-solving skills also possess the capacity to tailor solutions derived to previous stressors, and apply them to a new stressor (Mayer, & Wittrock, 1996), thereby increasing the likelihood that a future stressors will be overcome or adapted to.

According to D'Zurilla and Goldfried (1971), problem-solving skills are comprised of two components: problem orientation (referred to as social problem-solving self-efficacy), and problem-solving style (referred to as generalized positive problem-solving outcome). In social problem-solving theory, these two components are referred to as (1) social problem-solving self-efficacy (problem orientation), the belief that the problem can be solved and solutions implemented effectively; and (2) generalized social problem-solving outcome (problem-solving style), a general belief that problems are solvable (Nezu, 2004). According to Nezu (2004) positive self-efficacy and beliefs about outcomes increases the use of adaptive coping when subjected to a stressor, and vice versa. That is, if an individual believes they are capable

of overcoming a stressor and possess the necessary resources to achieve this, they are more likely to use adaptive coping strategies to overcome the problem.

Therefore, the focus of the resilience-building intervention will be to improve both participant perceptions about their ability to overcome a stressor, and provide the resources necessary to overcome a problem. However, interventions designed to improve problem-solving skills (and subsequently resilience) in frail older adults are lacking. Furthermore, Problem-Solving Therapy is not suitable for the current study as it is designed for individuals who are living within stressful circumstances but are unable to overcome them (Haley, 1987), whereas the resilience-building intervention emphasises prevention as much management. Additionally, research assessing the capabilities of Problem-Solving Therapy in building resilience in older adults is scarce. Therefore a new intervention must be developed, one that considers multiple components of resilience (in addition to problem-solving skills), and attempts to improve them simultaneously, and based on discussions within Chapter 1, these should be social support, self-efficacy, and optimism.

In considering the number of problem-solving activities to use within the intervention, D'Zurilla and Goldfried's (1971) Problem-Solving Therapy use up to 12 activities, but state that improvements to problem-solving skills become observable after eight activities are completed. Additionally, Barnes, Wang, and O'Brien (2017) emphasised the importance of ensuring that any and all tasks involved in building problem-solving skills must be within the capabilities, and representative of, the target sample as in situations where this is not the case no improvements in problem-solving skills were observed.

To improve feelings of social support it was considered that the intervention be completed in groups. Although completing problem-solving interventions in groups offers no additional improvement to problem solving skills when compared to individual interventions (Malouff, Thorsteinsson, & Schutte, 2007), group interventions do provide greater opportunity to improve feelings of social support (Heaney, & Israel, 2008). However, Cacioppo, Fowler,

Christakis, and Nicholas (2009) states that being in a large group does not provide feelings of social support, but that there needs to be a deepening of connectivity between group members, and if groups are too big this is unlikely to occur. Therefore, to improve social support group activities must also facilitate a deepening of bonds between members. Increasing social support also improves feelings of self-efficacy as it facilitates positive reinforcement and encouragement from peers (Prati, & Pietratoni, 2009).

According to Seligman (1995), optimism (which is in itself a form of resilience, Seligman, 1995) is comprised of two components: (1) the ability to realistically assess a situation (or in this case, the adverse impact of a stressor) and consider what can be changed to overcome the situation; and (2) successfully overcoming a problem. Therefore, by completing problem-solving activities in groups, feelings of optimism should develop naturally. This is because the impact of 'successes' (as described by Seligman, 1995) on optimism can also be attributed to solving hypothetical scenarios (Williams, 2014). Furthermore, completing the intervention in groups provides participants with the opportunity to discuss the impact of a problem, and consider realistic ways in which the problem can be overcome with peers.

Based on these considerations, the resilience-building intervention should contain a minimum of eight problem-solving tasks, be completed in small groups, and help develop lasting social ties between group members. These findings provide a generic outline for a resilience-building intervention, but do not indicate how to tailor the intervention for residents of ExtraCare retirement villages. To overcome this issue, the use of co-creation and considerations of feasibility was contemplated.

Co-creation is a process of intervention design whereby stakeholders representative of the target sample are incorporated into the intervention design process (Voorberg, Bekkers, & Tummers, 2015). In the context of this resilience-building intervention, the target audience is ExtraCare residents, and therefore stakeholders representative of this cohort would also be ExtraCare residents (but would not complete the intervention), as well as ExtraCare staff (due

to their knowledge of residents and the village resources). The role of the stakeholders is to provide their personal and professional opinions about the feasibility of the intervention. This involves evaluating the demands of the intervention against the capabilities of the participants, how this will impact on participant uptake and retention, the applicability of the intervention processes to the target sample (which in this intervention will be oriented towards improving problem-solving skills), and the likelihood of success based on the proposal (i.e. the intervention design) provided. According to Sanders and Stappers (2008) effective use of co-creation in intervention design can improve feasibility, reproducibility, and generalizability.

A feasibility study, commonly referred to as a pilot study, is a small study for helping to design a larger, future study (Arian, Campbell, Cooper, & Lancaster, 2010). This process involves completing a draft version of an intervention or programme and using a small sample to test the efficacy of the process, provide feedback following completion, and then amend the design based on their feedback. However, as we are using a process of co-creation, the need for a feasibility study is reduced. We will instead consider the feasibility of the generic template (i.e. length of the intervention, duration of meetings, group size and type of participants recruited) against the capabilities of candidate participants as part of the co-creation process. Therefore, the aim of the current study is to gauge the perspective of stakeholders representative of the target sample for the resilience-building intervention to build problem-solving tasks representative of the target sample, and to assess the feasibility of the intervention.

3.17. Aims

The aim of this study was to co-create a resilience-building intervention with stakeholders and to consider the feasibility of its implementation within ExtraCare settings.

3.18. Methods

3.19. Participants

A total of 17 participants (1 male, 16 female, aged 40 to 91) were recruited across four villages consisting of 12 residents (1 male, 11 females, aged 57 to 91), one member of the public volunteering to manage the cafeteria within the village, and four well-being advisors (aged 40 to 91).

The participants formed three focus groups. Group one was comprised of a well-being advisor and five ExtraCare residents. Group two consisted of a well-being advisor, three ExtraCare participants, and the community resident volunteering within the village. Group three consisted of a well-being advisor and four ExtraCare residents. The final participant (a well-being advisor) was consulted on a one-to-one basis.

3.20. Ethics

Informed consent was gained by providing participants with an information sheet outlining their rights of withdrawal and anonymity as participants and what the study entails. The mental capacity for participants to give informed consent was considered. This was done in collaboration with the well-being advisors in each village as they possess in-depth knowledge of any and all residents who were interested in taking part in the study.

Participants were informed and aware that all focus group meetings would be recorded for later review and analysis as part of intervention-building process, and were instructed to only use first names to ensure anonymity.

All sensitive participant information collected in which participants could be identified was kept on a password-protected computer, and the document containing the information was also password-protected.

As part of receiving ethical approval a template for the intervention was required (see Appendix G for intervention template). However, the template was amendable and subject to change as part of the feasibility and co-creation processes with participants.

All ethical procedures were aligned with BPS requirements and the study received a favourable opinion from the Aston University Life and Health Sciences Ethics Committee.

3.21. Procedure

Across three focus meetings, participants reviewed the intervention template and provided suggestions for change. Participants also discussed everyday issues they and other residents live with, and what their ideal outcome in relation to dealing with these issues. The problems discussed by participants were transformed into hypothetical problem-oriented tasks.

Participants were involved in a total of three meetings over a 6-week period, with each meeting template (as discussed below) implemented across the four retirement villages with the same participants.

Meeting 1 - The focus of meeting 1 was to co-create hypothetical problem-oriented tasks for the resilience building intervention.

Participants were given a copy of the intervention template, an explanation of the proposal and purpose of the intervention (i.e. build resilience via improving problem-solving skills), and how the intervention template would help achieve their goal. Participants were also given an explanation of their role in the design process and what we hoped to achieve through their participation. Participants were invited to ask questions if there remained any ambiguity about their role and the purpose of the focus groups.

Following this, participants were then invited to discuss everyday issues they, and other residents, deal with on an everyday basis (e.g. how to overcome a fall, and/or living with feelings of loneliness), and consider the ideal outcome in each of these scenarios. Participants were also questioned about other issues that were not mentioned but may be prevalent (all questions and potential directions are discussed in the Topic Sheet, see Appendix H).

Following the completion of the first round of meetings across all villages, a series of hypothetical scenarios were created based on the information provided by participants. These hypothetical scenarios would be used as the problem-oriented tasks in the resilience-building intervention. The hypothetical scenarios were based on the following issues:

1. Having a fall.
2. Deterioration of eyesight.
3. Having to give up driving (due to medical reasons).
4. Loneliness and social isolation.
5. Memory loss and anxiety.
6. Osteoporosis.
7. Providing care to a partner.

Meeting 2 - The focus of meeting 2 was to review the hypothetical scenarios co-created in Meeting 1, and to consider the feasibility and representativeness of outcomes based on participants experiences of seeing individuals live with these issues within the ExtraCare retirement villages.

Participants were provided with a drafted intervention, complete with the hypothetical scenarios based on information gathered in Meeting 1. On a week-by-week basis, all activities were discussed in-depth. Participants were tasked with identifying any issues with the

scenarios, such as if the beginning of the story is likely to cause the problem, or if the outcome can be realistically achieved by residents living in ExtraCare retirement villages.

After reviewing each activity, a review of the generic components of the intervention were considered. This involved reviewing the total length of the intervention, duration of meetings, group size, and the importance of each task.

Following the completion of Meeting 2 for all participants minor adjustments were made to the intervention template. This involved amending two of the outcomes to focus on management of the problem as opposed to completely overcoming the issue. It was also suggested that Week 12 (the activity in which participants provide feedback about their experiences of taking part in the intervention) be added into Week 11.

Several participants did outline a concern that the duration of the intervention may cause participant retention issues. Although participants were happy with the suggestion that if the time requirements are made clear during the recruitment process, then issues of retention will be reduced.

Participants consented to the intervention being completed within groups of four to six, and that activities will be completed on a weekly basis (citing the busy lifestyles of residents).

Meeting 3 - The purpose of Meeting 3 was to provide participants with the amended intervention, and then consider any final adjustments to the intervention.

Across all groups, participants were content with the intervention design, and no further adjustments were suggested.

3.23. Data Analysis

A Braun and Clarke (2006) thematic analysis was performed on the co-creation component of the meetings (Meeting 1). According to Braun and Clarke (2006) there are six phases to a thematic analysis:

1. **Phase 1 -** *Familiarising yourself with the data:* During this phase the process of familiarisation is designed to help identify consistencies across the data.
2. **Phase 2 -** *Generating initial codes:* Objective meaning is then given to the consistencies identified in Phase 1 by generating codes and apply them to the transcripts. According to Braun and Clarke (2006) there are two types of code generation: inductive[4] and deductive[2].
3. **Phase 3 -** *Searching for themes:* codes are grouped together to develop an underlying theme.
4. **Phase 4 -** *Reviewing the themes:* a review process of the themes to ensure that the theme is appropriately labelled and reflects the coded text attributed to it.
5. **Phase 5 -** *Defining and naming the themes:* transcripts are reviewed once again to assess if any further coded text should be attributed to the theme.
6. **Phase 6 -** *Producing the report:* produce the results of the Thematic Analysis.

The underlying concept of what the participants would discuss was pre-determined to focus on everyday problems they, or other residents, live with (deductive). However, the themes developed in relation to these discussions were purely based on the data gathered (inductive). The themes identified were used to develop the problem-solving tasks. The problem-solving tasks were created using a Mean-Ends Problem-Solving approach (MEPS, Platt, & Spivack, 1975). That is, a beginning and an outcome to a problem is presented, and it is the role of

[4]Inductive coding is 'data driven' and is not influenced by theory, but rather coding is based on meaning derived solely from the data. Alternately, deductive coding is 'theory driven' and the researcher enters coding with expectations and a desire to find a specific meaning within the data based on theory. Inductive coding provides a broader scope of data as a more generic approach to analysis is taken, but lacks the richness of data attributed to deductive coding (Braun, & Clarke, 2006).

participants to determine what steps are required (i.e. completing the 'middle' of the story) to arrive at the outcome of the story. The accuracy (i.e. the likelihood of the problem occurring as described, and that the outcome is realistic and achievable) of the hypothetical problem-solving tasks developed was also discussed.

Following this, participants discussed the feasibility of the generic components of the intervention design (Meetings 2 and 3). Discussions of feasibility and areas for change focused on the demands of the intervention placed on participants (considering factors such as the duration of the intervention, and the length and frequency of meetings), and the use of group activities (i.e. if the intervention should be completed within groups, and if so, the ideal size of each group, and mixture of participants within each group).

Participants were referred to as either residents or well-being advisors. This is because residents who live in the villages discuss their experiences from a personal perspective, and the well-being advisors from a professional standpoint, and therefore it is important to provide the distinction in quotes discussed.

All data was transcribed manually.

3.24. Co-Creation Thematic Analysis

From performing an inductive Thematic Analysis three underlying themes were identified: 1) maintaining health in ageing (for both robust and functionally limited individuals); 2) an emergence of social isolation and loneliness; and 3) barriers towards recovery from adversity.

3.24.1. Theme 1: Maintaining Health in Ageing

When participants were questioned about everyday issues, they consistently highlighted health issues as their primary concern. Participants discussed a need to either maintain their full health or as close to optimal health as possible. For example, one resident, who lived with physical impairments, cited a desire to maintain health despite her impairments.

> *'You can't keep dancing and exercising when you've lost your sight or your mobility and you can't get down on your own, you need help to keep that extra bit going, you need empowering.'* - Resident A, Group 2

When further discussing issues surrounding everyday life in ExtraCare retirement villages, participants cited further health conditions such as osteoporosis, having a fall, memory loss, and sight loss, as well as significant life changes such as having to give up your car, and being a primary carer for your partner. These issues were unanimously considered key, and in some cases, inevitable parts of the ageing process.

> *'There are a lot of people managing comorbidities, long-term issues, mobility issues is a common one'.* - Well-Being Advisor D, Group 4

> *'I think you're quite right in saying these are issues of everyday ageing'* - Resident A, Group 2

Underscoring the discussions about potential health concerns was an anxiety across all residents, especially in those who appeared robust about having to deal with these issues. For example, one resident cited that losing her car would be equivalent to losing her arm.

> *'My husband said 'when I retire why don't we go down to one car' and I said no, no, I…I can't, it would be like cutting my arm off, and so we have managed to keep my car. I mean we are able bodied so we can get out but it must be awful for someone who isn't.* - Resident G, Group 3

The feelings of anxiety surrounding the loss of the car could indicate the car represents more than a means of travel for practical considerations such as shopping, but a symbol of her independence, and therefore to lose her car would therefore directly impact on her beliefs around her independence. Another example where anxiety surrounding health was provided by a well-being advisor who described the case of a resident who came to her with anxiety towards falling, despite not having a fall yet.

> *'Fear of falling is very common, and the more falls people have had, the more frightened of falls they are. I have a lady in here yesterday, and even though she hasn't fallen, she has developed a tremor and has a fear of falling'.* - Well-Being Advisor D, Group 4

Similar to the participant who discussed losing her car, the case discussed by Well-Being Advisor D also displayed an underlying anxiety about a loss of health in a resident who remained robust and had not suffered a fall. It could be argued that this anxiety underpins a lack of knowledge and/or preparation of how to deal with the impact of such an event occurring, and therefore supports to use of health-oriented problem-solving tasks in the resilience-building intervention.

This theme has highlighted the focus on maintaining health and independence in older adults, and also emphasised an underlying anxiety about health, even in healthy older adults. This suggests that the problem-solving tasks should contain a large contingent of health-oriented hypothetical scenarios.

3.24.2. Theme 2: Social Isolation and Loneliness

Many of the participants had resided in the ExtraCare retirement village since its opening. At that time there were many 'meet-and-greet events' designed to help residents meet each other and familiarise themselves with the environment and its facilities. This led to a social community, where residents would greet one another in the hallway and would make people feel less isolated and lonely. However, following the conclusion of these events, participants had noticed a downturn in socialising between residents who moved into the village in more recent times. As described by Residents V and W, with one talking about how the atmosphere of the village has changed with fewer general greetings and the other discussing a lack of engagement with the community from newly arriving residents:

> *'The great thing about these meetings before we moved in is that as we have met people up and down the corridor, and in the lift, we automatically say hello, and we have noticed the change, I don't know if you've noticed this, but erm…newer residents and their visitors are not so good at greeting'* - Resident V, Group 1

> *'You get new people who move in, and stay in their apartments and don't get to mix straight away, and as residents do we know who these new people are, and it is getting to know these people that the problem is.'* - Resident W, Group 1

This concern was shared by a staff member who discussed some of her experiences. Despite being hired as a well-being advisor (i.e. a trained nurse designed to provide information and guidance in relation to an individual's health), she stated that individuals would come to her with personal issues and use her as a pillar of support.

> *'I get people coming to talk to me about all sorts, because some people have some horrendous problems going on in their personal lives, they really are and they're really struggling and they just want somebody to be a friend that they can…you know, but it's hard because I can't say ooh could you maybe get Mrs. So-and-so to have a coffee with you.'* - Well-Being Advisor A, Group 1

Another well-being advisor emphasised the impact of health, and how seemingly minor impairments such as hearing abnormalities can make individuals uncomfortable in communal areas of the village and therefore avoid them. This results in the resident feeling lonely and isolated from others.

> *'There are people who are socially isolated, even though they live in this environment because not everyone finds it easy to mix with other people, and I've found that some of the residents who have got hearing difficulties tend to isolate themselves because they can't cope with all the background noise, especially in the atrium. So rather than actually, that they can't hear, they back away and don't go to the social functions.'* - Resident U, Group 1

Additionally, one well-being advisor who took part in the study also noted this issue and how overwhelming it can be to move into an ExtraCare village as new residents are moving into an unfamiliar environment and do not know anyone. This advisor described making an information booklet for residents to help guide them to activities that may interest them (such as playing bridge, bowls, or join the knit and natter group) and hopefully meet new residents and develop social ties.

> *'I am in the process of putting together a pack for when I do assessments of health and well-being and I felt there was no information for them, so I am going to get together with the manager and head of activities and do a sort of booklet about information on classes, and I think that would be really good as well for it (talking about loneliness)'* - Well-Being Advisor C, Group 3

When discussing the availability of resources to help combat social isolation and loneliness within the villages, a change in resources was cited as a significant contributing factor. For example, a reduction of staff or volunteering was seen contributing to the occurrence of social isolation as the practices in place when new residents moved in have significantly reduced.

> *'We did have a befrienders group here, but that sort of petered out, you know when all the apartments were full it just petered out'* - Resident F, Group 3

This theme has demonstrated that social isolation and loneliness is a main issue facing many residents within the ExtraCare retirement villages, and therefore warrants justification to its inclusion as a problem-solving task in the resilience-building intervention.

3.24.3. Theme 3: Barriers towards Recovery from Adversity

A recurring contrast was noted between participants when discussing the potential for recovery and/or maintenance of health despite setbacks, and the barriers that need to be overcome in implementing effect strategies to facilitate this recovery. Participants either actively attempted to maintain their health and recovery from adversity, or accepted that health loss was a natural part of the ageing process and barriers were too substantial to overcome to improve health. For example, one participant (who believed that health loss was

inevitable) believed that a resident who suffered a stroke would not be able to recover due to the severity of her health following the adversity.

> *'We have got one of those (a resident who suffered a stroke), but I don't think she will get back to walking'* - Resident A, Group 2

In contrast, Resident B argued the significant improvements already made in her health, and how her attitude shaped this improvement when presented with the necessary resources to recover.

> *'X's had strokes, she's fought really hard, she had difficulty with her speech, and she overcame that, she can talk in a fashion to us that we understand and she has got to the stage where you can put a chair there and a chair there and she can walk unaided from one chair.'* - Resident B, Group 2

Participant A proceeded to describe her own experiences in attempting to receive help for her own condition (a loss of sight), and how utilising the National Health Services, paired with a loss of resources within the ExtraCare retirement village, made managing her health conditions harder as she did not have the resources she needed to help her potential recovery.

'I'm losing sight very rapidly, I've known that I'm losing sight and my optician said to get an emergency appointment with the health service, the consultant, because blah blah blah, and erm…I tried. Six months later, this week, I've got an appointment with the consultant, meanwhile I now know I have to be registered as partially sighted because it has taken six months to see a consultant, so its not that I haven't tried, and you say about resilience, but you couldn't have tried harder than I tried. - Resident A, Group 2

Participant A continued to discuss the loss of resources within the village and how it inhibits recovery and rehabilitation.

'We got support groups going for all the people with hearing problems for example, because we've got a large group of deaf living here, and we got a very experienced and very intelligent person, with an assistant dog, and she put forward huge amount of information, how to deal with a profoundly deaf person here. But no attention was paid to her.' - Resident A, Group 2

Following this, Well-Being Advisor B and Resident D intervened in the discussion to provide their own opinions. Well-Being Advisor B explained how, despite the loss of resources, there are still resources available designed to help residents. This could indicate her belief that the resources available are still substantial enough to help with recovery from severe adversity. Alternately, Resident D counter argued that the resources available are not as substantial as they once were. This could also indicate that she believed the loss of these resources significantly impacts on the ability for people to recover from adversity.

'But there still are support groups available to people in the village' - Well-Being Advisor B, Group 2

'But when you compare to when the village opened, you were falling over the staff, but most of them got 3-month contracts and are no longer here.' - Resident D, Group 2

The contrast in opinion towards overcoming barriers that inhibit recovery was consistent across all focus groups. Unsurprisingly, individuals' attitudes towards recovery are shaped by their previous experiences. However, the source of the negative perspective varies between participants. For instance, Resident A shows good coping strategies by trying to directly tackle the problem (positive adaptive coping), but was unable to overcome the problem because of the unavailability of what she needed (i.e. an emergency appointment with the health service). Alternately, Resident D speaks about the loss of staff within the ExtraCare village and cites this as her main concern for poor support when faced with adversity, but this perspective directly contradicts ExtraCare's policy of volunteering for residents, which expects them to organise their own informal support groups. It is therefore unlikely that unless a shift in perspective is observed towards a positive outlook, as well as focusing on what can be achieved on an individual basis; recovery following adversity despite the presence of barriers is unlikely.

3.25. Considerations to Feasibility

Following the co-creation of the problem-solving tasks (based on discussions in Meeting 1) and agreement regarding the problem-solving tasks, Meetings 2 and 3 aimed to evaluate the feasibility of the broad components of the intervention. Participants discussed the length of

the intervention, the use of group activities, and the need for variation between participants within the intervention groups.

3.25.1. Length of Intervention

Several of the residents raised concerns that, at 12-weeks, the intervention is too long which may cause drop-out, and also that ExtraCare residents have very busy lifestyles which may make fitting in a weekly meeting difficult.

> *'The trouble you have is slotting it in, and finding a room available'* - Resident D, Group 4

Another resident suggested that to reduce the time demands of the intervention, Week 12 (which was a week for the participants to discuss and reflect on their experiences of taking part in the intervention) be incorporated into Week 11.

Based on these findings, three alterations were made:

1. Week 12 was incorporated into Week 11 to reduce time demands on participants.
2. During the recruitment process, participants are made aware of the requirements, and are given the timetable for the intervention.
3. The time and day of the week in which the activities would be completed remained consistent throughout the duration of the programme.

3.25.2. Use of Group Activities

The notion of completing the programme as a group was well-received by participants, with one noting that mental health services adopt a similar approach and yield more beneficial outcomes as a result of this.

> *'That is why the mental health services around here and elsewhere are flourishing because they are using groups to resource and establishing values and self-esteem, and it's working much better than the old way of you're ill you need counselling.* - Resident A, Group 2.

Participants also agreed that this process should be about meeting new people and reducing the risk of social isolation and loneliness, the groups should be relatively small. In this situation, residents who may be shy are more likely to take part as there are fewer people to meet, and also potential participants are more likely to share their own experiences and contribute to the meetings because there are fewer people involved in the discussion.

Based on the discussions between participants regarding group size, no adjustments were made to the intervention template based on group activities.

3.25.3. Type of Participant

A final concern that was raised by the participants was the recruitment process implemented i.e. by using posters on the notice boards and giving talks at street meetings[5]. That is, residents who attend the street meeting and review the poster board are generally more active and integrated in the village, and therefore may not benefit as much from the resilience-building intervention compared to residents who are less involved in the community.

[5]A street meeting is a monthly occurrence in ExtraCare retirement villages where residents of the village come together and are given updates about upcoming events in the village, policy change, and issues residents are dealing with are discussed.

> *'It has to be…for it to be really useful to you, it has to be a very diverse six. It has to be somebody who has to be brought out of their room because they can't get down, it has to be somebody young, somebody old, somebody who's been here a long time, someone who thought they were going to get this this and this.* - Resident A, Group 2

> *'It would be really lovely if you could see six people who never leave their flats'.* - Resident D, Group 2.

However, it was also recognised that accessing these individuals would be a complex challenge as many of the residents who would benefit most from the resilience-building intervention do not attend the street meetings or view the poster board, and would therefore not be made aware of the resilience-building intervention, or their carer is unwilling to bring the resident into the communal area to engage in the resilience programme.

> *'The people you're looking to empower, and make more insistent, are the people on the verge of dropping out, and there's a huge problem of social isolation here.'* - Resident A, Group 2.

Therefore, no adjustments were made to the intervention template or recruitment process based on the type of participant recruited.

The finalised resilience-building intervention is viewable in Appendix I.

3.26. Discussion

The purpose of this study was to develop and refine a resilience-building intervention to tailor it to residents of ExtraCare retirement villages using a combined feasibility (Arian *et al.,* 2010) and co-creation (Voorberg, Bekkers, & Tummers, 2015) approach. This was done through identifying underlying themes surrounding everyday problems faced by residents within these villages, and developing problem-solving skills based on these themes. The study then considered participants life experiences to assess the feasibility of the overall resilience-building intervention and adjusted the intervention based on participant recommendation.

Three themes were identified 'maintaining health in ageing', 'social isolation and loneliness', and 'barriers towards recovery and coping'. These themes provided direction and operated as the underpinnings for the development of the co-created problem-solving tasks which would be used in the resilience-building intervention.

The theme '*health in ageing*' was derived from exploring everyday issues older adults face in ExtraCare settings. Similar to findings by Mathews *et al*. (2010), this theme identified the importance of health in everyday life of older adults. However, Mathews *et al* (2010) discovered that health concerns were defined as barrier towards everyday activities, yet when discussing practical components of everyday such as visiting friends and family outside the retirement village, or travelling to the shops, participants did not consider these as significant issues. This can be attributed to the availability of resources within ExtraCare retirement villages as they are designed to be self-enclosed and sustainable if residents desire it (Holland *et al.,* 2015; 2017), whereas participants recruited by Mathews *et al* (2010) were from local communities, and therefore resources are not as readily available. This means that for ExtraCare residents, everyday necessities such as shopping and socialising are achievable despite the presence of health impairments. Matthews *et al*. (2010) did, however, suggest that a method to reducing these barriers in older adults would be to make participants aware of all resources available to them in relation to completing everyday tasks i.e. implement a

knowledge-building process. This process is similar to the principle of the resilience-building intervention in that the intervention is oriented towards improving the effectiveness of coping strategies implemented by improving knowledge of everyday stressors, which includes resources available to help overcome them.

An unexpected contradiction was also observed. Typically impaired health is associated with increased feelings of anxiety about health (Himmerfarb & Murrell, 1984; Simning, Fox, Barnett, Sorensen, & Conwell, 2018), yet in the focus groups it was participants living with a degree of functional impairment that offer a relaxed undertone when discussing health concerns, and the robust individuals feeling more anxious about health deterioration. It is plausible to attribute this anxiety discovered in the thematic analysis to Hobfoll's (1998) Conservation of Resources (COR) theory, which states that psychological stress occurs when individuals are threatened with resource loss, lose resources, or fail to gain resources following resource investment. In the context of findings from the thematic analysis, the anxiety discovered in robust participants is attributed to a greater perceived threat of resource loss which is caused by living with individuals who have previously lost resources, and are therefore frailer. Indeed, qualitative work by West, Shaw, Hagger, and Holland (2017), which evaluated discourse, identity, and liminality in ExtraCare communities, discovered that living around older and frailer residents created a fear within robust residents of themselves becoming frail. COR also states that individuals who have fewer resources (such as frail participants) focus on resource maintenance and reduce the risk of resource loss by foregoing attempts to gain resources. That is, management of health instead of attempts to improve it. Therefore, those who are able to achieve this do not feel psychological stress, despite having fewer resources, as those who fear resource loss.

The theme '*Social Isolation and Loneliness*' highlighted a prevalence of social isolation and loneliness with ExtraCare villages. This is unsurprising as according to the Office for National Statistics (Thomas, 2015), loneliness and social isolation is one of the main concerns

of older adults, with 21% of older adults aged 65 and over, and 33% of older adults aged 80 and over, reporting feelings of loneliness. The average age of ExtraCare residents who took part in Holland *et al's* longitudinal study is 76. Whilst Holland *et al* (2019) did show that the average feelings of loneliness in ExtraCare residents were lower than the national average; feelings of loneliness were still present. However, participants of the focus groups indicated that it was not themselves who were lonely, but that they observed individuals who were lonely in the village. They theorised that these people who are lonely do not engage with activities and other residents in the village for varying reasons and that is the reason for their loneliness. This would suggest that those residents did not engage in research completed by Holland *et al* (2019). This theory is supported by the change of atmosphere noted by the focus group participants, who stated that residents rarely greet one another in corridors whereas this was previously commonplace. As noted by Participant Y, who is also a well-being advisor, she has residents seeing her to talk about their issues as opposed to any health concerns. It is possible this is attributed to the reduction is resources within the villages reducing the pathways in which new residents may integrate themselves into the villages. Yet this also emphasises the need to incorporate social isolation and loneliness into the problem-solving tasks, and also to attend to any potential feelings of loneliness participants may have. Addressing this issue further supports the use of group-oriented activities in the resilience-building intervention (Cattan, White, Bond, & Learmouth, 2005).

The third and final theme '*Barriers towards Recovery from Adversity*' highlighted the importance of the availability of resources when facing adversity. For instance, Resident D presented a degree of helplessness regarding adversity management because of a reduction in staff within ExtraCare villages (despite ExtraCare policy emphasising volunteering in relation to running village facilities and informal support groups). Alternately, Resident A spoke about how she attempted to deal with her eyesight issue (i.e. positive adaptive coping), but the

resources necessary for this were not available to her. As a result she is not considered partially blind.

These experiences regarding recovery from adversity shape attitudes towards recovery, and a failure to achieve the desired outcome creates a pessimistic outlook about future adversities, which can impair recovery or adaptation to adversity (Conversano *et al.,* 2010; MacLeod *et al.,* 2016). This suggests that the resilience-building intervention will need to provide more than an awareness of methods of overcoming adversity, but also provide a change in beliefs about the capacity to overcome adversity despite the presence of barriers. Yet optimism can be learned by increasing an individual's sense of control in relation to their health and the adversity faced (Fontaine, Manstead, & Wagner, 1993; Peterson, 2000; Schneider, 2001). In relation to the issue faced by Resident A, improving her sense of control could be achieved by increasing her awareness of local organisations that help people living with eyesight problems. Alternately, Resident D's sense of control could improve by using ExtraCare resources available to residents to form a support group. However, it is also important to maintain a realistic outcome based on the adversity faced. For example, Resident A should not believe that it is possible to recover her sight, but instead her goal should instead be to cope with her partial sight loss and continue to engage with her leisurely activities. Alternately, Resident D should not expect an informal social support group to provide as much security and support as the professional staff that no longer work at the village.

This means that the resilience-building intervention should consider how to improve participants knowledge of the resources available to them in the local community in relation to the hypothetical problems discussed. This should improve their sense of control, and therefore provide a more optimistic outlook when faced with adversity. However, it is also important that participants completing the intervention possess a level of self-awareness as to what can realistically be achieved.

The use of these three themes as the foundation for developing problem-solving tasks with participants for the resilience-building intervention was accurately and effectively completed. Participants consistently cited experiencing similar scenarios themselves or situations they frequently see in other residents in ExtraCare settings, such as having a fall, or living with comorbidities. This, paired with the feasibility considerations, resulted in participants being unanimously in agreement about the design of the intervention, its purpose, and that it will be able to operate effectively in ExtraCare retirement villages.

3.27. Strengths and Limitations

Overall, a good range of themes were identified which helped improve representativeness of the problem-solving tasks towards older adults living in ExtraCare settings. In addition, the feasibility considerations helped define and shape procedure for the implementation of the resilience-building intervention from the process of recruitment up to the completion of the programme.

However, a gender imbalance was present which may reduce the representativeness of the problem-solving tasks towards older males.

3.28. Conclusion

The purpose of this study was to identify underlying themes surrounding everyday issues of ExtraCare residents, and to use those themes as the foundation for developing problem-solving tasks representative of issues face by ExtraCare residents. Three themes were identified which were used to develop problem-solving tasks for the resilience-building intervention. Further adjustments to the intervention were also made based on the considerations of feasibility.

Upon the completion of Meeting 3, there was unanimous agreement from participants that the hypothetical problem-solving scenarios created (based on the health conditions identified in Meeting 1) were realistic and representative of issues faced by residents of ExtraCare retirement villages. Therefore, it can be concluded that the process of co-creation with residents and well-being advisors was effective in creating hypothetical problems that candidate participants (of the resilience-building intervention) can relate to, and therefore are more likely to engage with.

It was also concluded that beyond providing participants with problem-oriented tasks, the intervention must also aim to improve participants sense of control regarding their own health (and therefore increase feelings of optimism), and also increase participant knowledge of the resources available within local communities that may help overcome a stressor. However, it was also concluded that in tandem with increasing optimism, that when facing adversity, participants are able to contemplate realistic outcomes based on the stressor faced.

Chapter 4

Building Resilience in Older Adults

4.1 Chapter Aims

In Chapter One we queried the conceptualisation and operational understanding of resilience in the context of frailty, and highlighted the primary issues surrounding this ambiguity. Three concerns were raised: (1) an ambiguous and inconclusive conceptualisation as to what resilience is in the context of frailty. For instance, Rockwood and Mitnitski (2015) argue that resilience and frailty are mutually exclusive, whereas Witham and Sayer (2015) and Holland *et al* (2018) theorise that resilience is present in frail older adults. Additionally, Herrman *et* al (2011) theorise that resilience in the context of frailty is considered a unidimensional physiological construct; whereas Cosco *et al* (2017) and Holland *et al* (2018) argue towards the importance of psychological resilience. (2) Unsurprisingly, this has resulted in a lack of understanding towards what the benefits of building resilience in older adults are. Cosco *et al* (2017) conceptualise the presence of resilience in older adults as functioning beyond what is expected based on their health. Although it remains unclear if Cosco's representation of resilience is oriented towards physiological resilience as opposed to psychological. Holland *et al* (2018) cite numerous benefits such as quality of life when improving psychological resilience, but argue that more research is required to substantiate their findings. (3) The focus on improving resilience in children and young adults (Windle, Salisbury, & Cielsa, 2010) subsequently means that research examining resilience in older adults is scarce.

These issues have since been addressed. In Study 4, we identified the potential for psychological resilience (defined as a process of coping and adaptation, Cosco *et al.*, 2017) to have a beneficial effect on frailty (assessed using the FI38) as it predicts loneliness, perceptions of environmental age-friendliness, and depressive symptomology. Resilience also marginally predicted feelings of exhaustion, another component of frailty assessment. In addition to the direct benefit on frailty, it is plausible that resilience may improve frailty outcomes as it predicted both quality of life and anxiety symptomology. These previous findings provided evidence towards our theory regarding the importance of psychological

resilience in frailty (as discussed by Holland *et al.*, 2019), that resilience is not just a physiological construct, as postulated by Rockwood and Mitnitski (2015), but also a psychological resource that helps reduce both frailty and some of the adverse outcomes associated with frailty.

Following this, in Study 5, an intervention for building resilience in older adults was developed using recurring by considering the key markers of resilience (as discussed in Chapter 1), and using a co-creation and feasibility approach to tailor the intervention to be representative, and meet the capabilities, of residents of ExtraCare retirement villages. The intervention attempts to build resilience in older adults as a bi-product of improving problem-solving skills (Prati, & Pietratoni, 2009). The final, and current, stage is to implement the resilience-building intervention and determine what, if any, improvements are made. Therefore the aim of Chapter Four is to implement and analyse the effectiveness of the resilience-building intervention.

4.2 Study Six: Building Resilience in Older Adults

4.3. Introduction

Improving problem-solving skills has shown to increase resilience across from childhood (Zolkoski, & Bullock, 2012), to adulthood (Tenhula *et al.*, 2014). This occurs as greater problem-solving skills provide the individual with more internal resources to develop effective adaptive and/or emotional strategies towards a stressor (Prati, & Pietratoni, 2009). Based on findings from Study 4, we can suggest that increasing resilience will have a beneficial impact on frailty and outcomes.

In Study 5, we co-created a problem-solving intervention that is tailored towards older adults living in ExtraCare retirement villages. The next, and final, stage is to implement and evaluate the effectiveness of the intervention in terms of improving problem-solving skills and building resilience. We will also consider findings from Study 4 and determine if improving resilience will have a beneficial impact on frailty (by reducing feelings of depressive symptomology, feelings of exhaustion, and feelings of loneliness, as well as improve perceptions of environmental age-friendliness), and if the frailty outcomes quality of life and anxiety symptomology also show improvement.

4.4. Aims

1. Assess if a significant improvement to Mean-Ends Problem Solving is observed, and if this has translated into an increasing of psychological resilience.
2. Assess if a significant improvement in assessments of frailty (loneliness, depressive symptomology, and perceptions of environmental age-friendliness) and frailty outcomes (quality of life and anxiety symptomology).
3. Assess if any significant improvements observed are maintained from Time 2 to Time 3, and if not consider potential covariates that may account for this.

4.5. Method

4.6. Participants

A total of 43 participants (14 male, 29 female, and aged 58-96) were recruited from six ExtraCare retirement villages. During the course of the programme a total of four participants withdrew from the study citing health reasons. Therefore a total 39 participants were eligible for analysis (12 male, 27 female, aged 58 to 96).

4.7. Ethics

Recruitment posters (see Appendix J) were placed on notice boards in ExtraCare retirement villages, and presentations and informal talks given about the intervention to residents. Prior to participation, participants received an information sheet fully explaining their rights as participants, their rights to anonymity and to withdraw at any point during the study if they wish (see Appendix K). Participants were also provided a copy of the intervention prior to their participation so they could view in its entirety what was involved in the intervention and make an informed decision with regards to their participation. The mental capacity of participants to give informed consent prior to taking part in the project was considered in conjunction with the Mental Health Act (2007). During each data collection stage participants were reaffirmed of their rights as participants. As participants were fully briefed on the study prior to their participation no debriefing was required. All ethical procedures are aligned with the British Psychological Society, and the study was given a favourable opinion from the Aston University Life and Health Sciences Ethics Committee.

4.8. Measures

The assessments used to evaluate quality of life, anxiety and depressive symptomology, and feelings of exhaustion are the same as those used in Studies 1 and 2. Assessments of loneliness and perceptions of environmental age friendliness are the same as those used in Study 3. The scale used to assess resilience, is the Connor-Davidson Resilience Scale (Davidson, 2018) used in Study 4.

4.8.1. Means-End Problem Solving Test

Developed by Platt and Spivack (1975), the Means-End Problem Solving test is a problem-solving skills assessment. This test assesses the ability of participants to produce solutions to hypothetical scenarios. In this test, participants are given four hypothetical scenarios, a beginning and an end in each situation, and are asked to imagine themselves in this situation, and consider what steps they would take to achieve the end of the story provided. Scores are derived based on the amount of active steps an individual suggests to achieve the outcome. For example, in a hypothetical scenario where the participants partner leaves them following an argument, a score of three would be achieved for the following steps: (1) giving the partner time to calm down following the talk so rational talks could take place; (2) talking with the partner and discussing each person's grievances and issues that caused the argument; and (3) suggesting marriage counselling to help delve deeper into unresolved issues. When all four scenarios are completed, an average score is derived from the scores of the four hypothetical scenarios.

The hypothetical scenarios used to assess participants problem-solving skills are based on Goddard *et al's* (1996; 1997) situations: making friends in a new neighbourhood, a break-up of a relationship, falling out with a friend, and problems with a boss in the workplace. However, as this test was administered on three occasions, to reduce the risk of a repeated

testing bias (where participants scores improve from completing the same test on multiple occasions as opposed to improvements from an intervention), different scenarios were devised for each time frame, although they were similar, but contextually different, situations to those developed by Goddard *et al* (1996; 1997; see Appendix L).

4.8.2. Additional Measures

The number of meetings participants attended was also recorded, and participants were asked if they had been subjected to a new stressor during their participation in the project.

4.9. Procedure

Using cluster randomized controlled trials based on village of residence; participants were allocated to one of two conditions: the 'intervention' condition, or the 'delayed intervention' condition. Of the 37 participants who completed the intervention, 17 were allocated to the 'intervention' condition (7 male, 10 female, and aged 58 to 89), and 20 to the 'delayed intervention' condition (3 male, 17 female, and aged 68 to 96).

There are a total of three time periods in the study. At Time 1, participants in both conditions completed a series of assessments (as outlined in the measures section). Between Time 1 and Time 2, participants in the 'intervention' condition completed the resilience-building intervention, whilst participants in the 'delayed intervention' condition took no action. This allowed participants in the 'delayed intervention' to act as the control for participants completing the intervention. At Time 2, following the completion of the intervention, all participants completed another assessment. Participants in the 'delayed intervention' condition then completed the 11-week programme whilst participants in the 'intervention' condition took no further action. Following the completion of the intervention (Time 3) all participants completed their final series of assessments.

After each group completed the resilience-building intervention semi-structured group interviews were performed. In the interviews, participants were asked three questions: (1) what did you enjoy about the intervention? (2) What did you dislike about the intervention? and (3) what would you change in the intervention? Following each question further unscripted questions were asked depending on participant responses to further gauge their perspective about their experiences of the intervention.

4.10. Design & Analysis

This study adopted a mixed methods approach to data analysis (the use of quantitative and qualitative analysis to analyse and draw meaningful conclusions from the data, Hanson, Creswell, Plano-Clark, Petska, & Creswell, 2005). Quantitative analysis was given a primary status and qualitative secondary, which means that the focus of qualitative thematic analysis (such as the themes that were examined, meaning the thematic analysis was deductive) was determined by findings from the quantitative analyses.

4.10.1. Assessing for Ceiling/Floor Effects

To assess for ceiling effects two methods were implemented. According to Terwee *et al* (2007) if more than 15% of participants possess the maximum score for a variable, ceiling effects are present.

According to Wang, Zhang, McArdle, and Salthouse (2008), there are three methods for overcoming ceiling effects: (1) listwise removal of participants with the ceiling/floor effect data; (2) consider the ceiling effects as ‘missing data’; and (3) implement the Tobit Growth Curve model. Listwise removal, whilst a simple solution to implement, presents issues when participant removal significantly impacts on sample strength. Similarly, considering specific ceiling/floor effects as ‘missing data’ presents similar issues to sample strength as listwise

removal of data, but with reduced severity as it is only applicable to specific analyses involving the variable(s) where ceiling/floor effects are observed. Implementing a Tobit Growth Curve approach does not have an impact on sample strength, but requires longitudinal data necessary to perform growth modelling, which is lacking in the current study, and is therefore not a viable option. Therefore, considering ceiling/floor effects as missing data is the approach taken in this study.

4.10.2. Intervention Outcomes

A series of two-way ANOVAs were performed from Time 1 to Time 2 to assess for a significant improvement to feelings of loneliness, perceptions of environmental age-friendliness, depressive symptomology and feelings of exhaustion. Outcomes of frailty such as quality of life, and anxiety symptomology were also assessed.

4.10.3. Retention of Benefits

To assess if any benefits gained from the intervention are retained, paired-samples t-tests will be performed between each time point (i.e. Time 1 and Time 2, Time 2 and Time 3, and Time 1 and Time 3). This will help determine if, firstly, there was a significant change in outcomes between Time 2 and Time 3 (i.e. retention of benefits), and secondly, if there is a significant change between Time 2 and Time 3 (such as a significant decrease) are scores at Time 3 significantly higher than scores at Time 1, which would indicate some retention of benefits. As this analysis requires a follow-up assessment, only participants in the 'intervention' condition were eligible for the analyses.

4.10.4. Assessing Covariates

In the event a significant decrease in problem-solving skills is observed from Time 2 to Time 3 for the 'intervention' condition, a repeated-measures Analysis of Covariance will be performed, with the number of intervention meetings attended (which is shown to have an impact on problem-solving skills, D'Zurilla, & Goldfried, 1971) utilised as the covariate. Similarly, if a significant reduction in resilience is observed from Time 2 to Time 3, participants will be grouped based on if they have been subjected to a new stressor or not (which is shown to challenge the maintenance of resilience, Windle, (2011)) to determine if this influenced the reduction in resilience. If further reductions in quality of life and anxiety and depressive symptomology are observed, it is expected this will be a consequence of the reduction in resilience, and therefore no considerations will be made for these variables.

4.10.5. Deductive Thematic Analysis

A Braun and Clarke (2006) deductive thematic analysis (see Study 5 for more details) was performed with themes based on findings (or lack of) from quantitative analysis. For example, if a significant improvement in social problem-solving skills (based on mean-ends problem solving assessment) what qualitative evidence is available to support the quantitative findings?

All quantitative analyses were conducted using SPSS Statistical Analysis Version 25.

4.11. Results

4.11.1. Assessment of Ceiling/Floor Effects

The assessment of ceiling/floor effects was restricted to Time 1 of the intervention process. Frequency analyses show that ceiling/floor effects were identified for the assessments of

perceptions of environmental age-friendliness (17.9%, 7 participants removed), and feelings of loneliness (50%, 19 participants removed) and feelings of exhaustion (71.1%, 27 participants removed). Floor effects were observed for anxiety (15.8%, 6 participants removed) and depressive symptomology (26.3%, 10 participants removed). Ceiling effects were not considered present in Mean-Ends Problem-Solving (0%), quality of life (0%).

Following the removal of participants where ceiling effects were found meant that a total of 32 participants were retained for analyses involving perceptions of environmental age-friendliness (14 intervention, and 18 delayed intervention), 19 for assessments regarding feelings of loneliness (10 intervention, 9 delayed intervention), 28 participants for assessments regarding depressive symptomology (), and 32 participants for anxiety symptomology.

Feelings of exhaustion was removed from the study as only 11 participants were eligible for analysis (5 intervention, 6 delayed intervention).

4.11.2. Descriptive Statistics

The mean, standard deviation, median, interquartile score, and range of scores for participants (separated into conditions, and also as a total for each time period) resilience, means-ends problem-solving (MEPS), quality of life (QoL), anxiety (HADS_A) and depressive symptomology (HADS_D), feelings of loneliness, and perceptions of environmental age-friendliness (AFEAT) scores are presented below in Table 23.

Table 26*: Descriptive Statistics between Groups at each Time Period.*

	Group		*n*	Mean	Std. Dev	Median	IQ Range	Range
Time 1	Intervention	Resilience	17	30.94	6.64	31	14	19-38
		MEPS	17	9.53	3.62	9	7	5-17
		QoL	17	38.18	6.09	39	9	24-47
		HADS_A	12	5.83	5.078	5	9	1-17
		HADS_D	13	4.25	3.864	2.5	7	1-12
		Loneliness	10	10.40	.699	10.50	1	9-11
		AFEAT	14	41.21	6.028	42.50	9	27-49
	Delayed Intervention	Resilience	22	32.22	7.40	33	10	16-40
		MEPS	21	8	2.69	8	4	3-14
		QoL	20	38.17	5.67	39.5	9	25-47
		HADS_A	15	2.93	2.344	2	3	1-8
		HADS_D	15	3.5	1.883	3	3	1-7
		Loneliness	9	9.55	1.236	10	3	8-11
		AFEAT	18	41.11	6.685	41.50	8	23-49
	Total	Resilience	39	31.73	7.06	33	12	16-40
		MEPS	38	8.58	3.12	9	4.5	3-17
		QoL	37	38.17	5.78	39	9	24-47
		HADS_A	27	4.22	4.003	2	6	1-17
		HADS_D	28	3.88	2.997	3	3	1-12
		Loneliness	19	9.95	1.079	10	2	8-11
		AFEAT	32	41.16	6.305	42	8	23-49
Time 2	Intervention	Resilience	17	31.35	6.11	32	9	19-40
		MEPS	16	11.25	4.12	11.5	7	5-19
		QoL	17	37.35	7.73	39	9	20-48
		HADS_A	12	3.17	3.099	2	3	1-12
		HADS_D	13	3.58	4.316	2.5	6	0-14
		Loneliness	10	9.70	2.163	10	4	6-12
		AFEAT	13	42.69	5.544	42	7	29-50
	Delayed Intervention	Resilience	22	32.38	5.88	34	10	17-40
		MEPS	22	7.24	1.79	8	3	3-10
		QoL	19	37.33	7.38	38	13	24-47
		HADS_A	15	2.87	3.502	2	3	0-14
		HADS_D	15	3	2.664	3	5	0-7
		Loneliness	9	9.33	2.179	10	4	6-12
		AFEAT	18	41.67	4.589	42	6	34-50
	Total	Resilience	39	31.92	5.93	33.5	9	17-40
		MEPS	38	8.97	3.59	8	4.5	3-19
		QoL	36	37.34	7.44	38	12	20-48
		HADS_A	27	3	3.270	2	3	0-14
		HADS_D	28	3.29	3.52	2.5	5	0-14
		Loneliness	19	9.53	2.118	10	5	6-12
		AFEAT	31	42.10	4.989	42	7	29-50

	Intervention	**Resilience**	13	28.50	6.27	29	9	18-40
		MEPS	13	9.18	3.58	9.5	5.5	5-18
		QoL	13	36.81	7.58	38	7	17-46
		HADS_A	12	4.08	2.344	2	3	1-8
		HADS_D	12	4.17	4.282	2	5	1-13
		Loneliness	9	9.56	1.014	10	2	8-11
		AFEAT	13	41	5.066	42	9	33-48
Time 3	**Delayed Intervention**	**Resilience**	14	33.25	4.29	34	5	22-40
		MEPS	14	7.56	2.10	7	2.75	4-13
		QoL	14	38.06	5.88	40	9	28-47
		HADS_A	15	2.2	1.781	2	2	0-7
		HADS_D	12	3.25	2.417	2.5	4	1-8
		Loneliness	6	11	1.673	12	3	8-12
		AFEAT	14	40.60	3.757	40	6	35-48
	Total	**Resilience**	27	30.83	5.64	32.50	9	18-40
		MEPS	27	8.15	2.99	8	4	4-18
		QoL	27	37.61	6.70	39	8	17-47
		HADS_A	27	3.04	2.915	2	2	0-11
		HADS_D	24	3.71	3.432	2	4	1-13
		Loneliness	15	10.13	1.457	10	3	8-12
		AFEAT	27	40.79	4.332	8	8	33-48

4.11.3. Intervention Outcomes

The two-way repeated measures ANOVA to assess for a significant difference for resilience, mean-ends problem-solving, quality of life, anxiety and depressive symptomology, feelings of loneliness, and perceptions of environmental age-friendliness between the conditions 'intervention' and 'delayed intervention' (which operates as the control condition in this analysis) from Time 1 to Time 2 is presented below in Table 27.

Table 27: *Repeated Measures ANOVAs between Conditions from Time 1 to Time 2*

	n **(int/control)**	**F**	***p***	**Partial Eta Squared**
MEPS	16/21	8.012	.008	.186
Resilience	17/22	.532	.471	.014
Quality of Life	17/18	.397	.533	.012
Anxiety Symptomology	13/19	10.216	.003	.254
Depressive symptomology	13/15	.333	.569	.013
Loneliness	10/9	.430	.521	.025
AFEAT	13/18	.348	.560	.012

*** Analyses show the intervention between conditions (intervention vs. control)*

The repeated-measures ANOVAs showed a significant improvement in mean-ends problem solving (MEPS) scores, as well as a significant decrease in anxiety symptomology, for participants in the 'intervention' condition compared to the 'delayed intervention' condition (which operated as the control condition in the analyses, see Figures 9 and 10). A trend was displayed, showing an improvement in 'intervention' participants' resilience, whereas 'delayed intervention' participants resilience remained stable. However, this was not significant. There was also no significant improvement in 'intervention' participants' depressive symptomology, feelings of loneliness, or perceptions of environmental age-friendliness.

Figure 9 (see below) shows an improvement in MEPS scores for participants in the 'intervention' condition, while participants in the 'delayed intervention' condition (who did not receive the intervention between Time 1 and Time 2) show a minor decrease in their average MEPS scores.

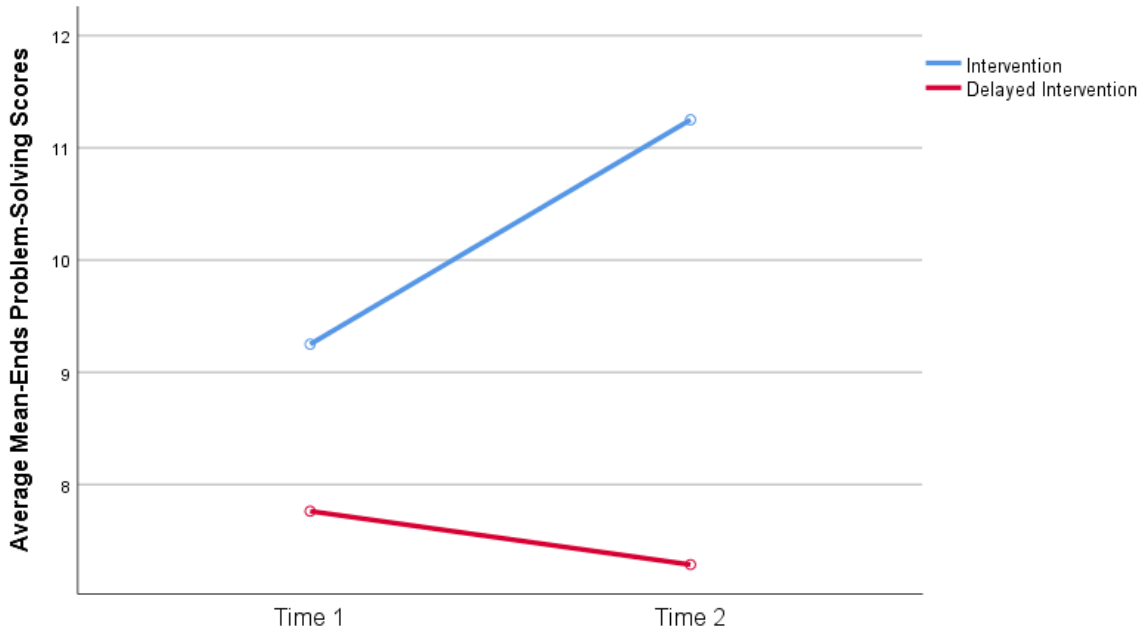


Figure 9: *A Graph showing the change in MEPS scores for Participants from Time 1 to Time 2 between Conditions.*

As shown below in Figure 10, there is a significant decrease in anxiety symptomology scores for participants in the 'intervention' condition, whilst the average anxiety symptomology scores for participants in the 'delayed intervention' condition remained near constant.

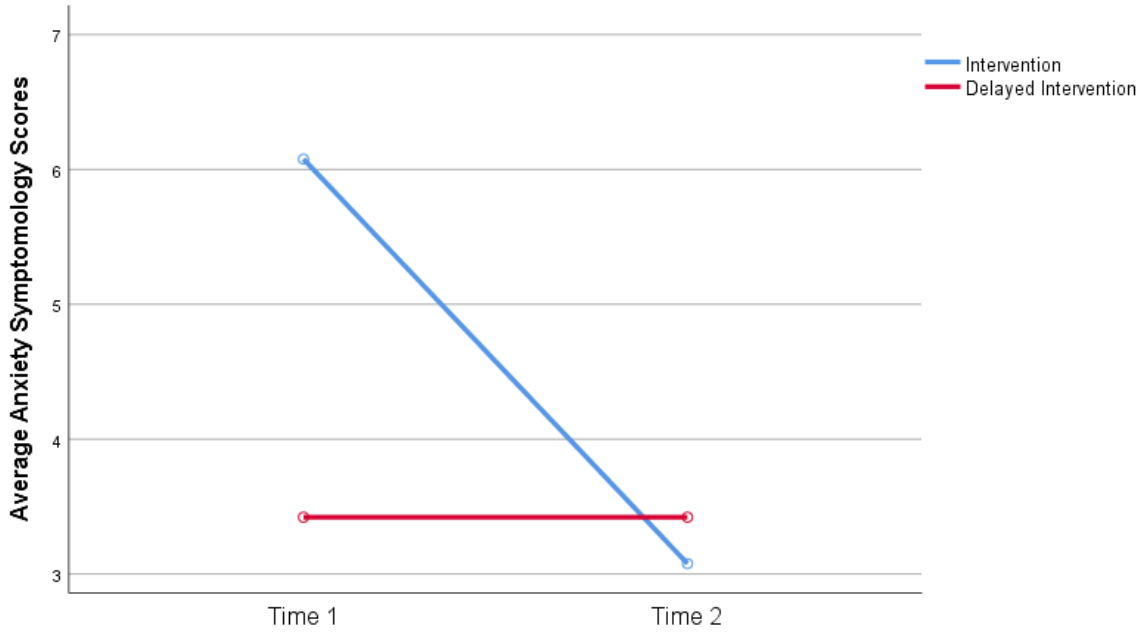


Figure 10: *A Graph Displaying the Change in Anxiety Symptomology from Time 1 to Time 2 between Conditions.*

4.11.4. Retention of Improvements

Results of the paired-samples t-tests between the three time points for 'intervention' participants' mean-ends problem-solving and anxiety symptomology scores are presented below in Table 28.

Results from the paired-samples t-tests show that the improvement observed in 'intervention' participants MEPS and anxiety scores from Time 1 to Time 2 was significant. There was, however, a marginally significant reduction in MEPS, and non-significant increase in anxiety symptomology scores from Time 2 to Time 3. Unfortunately, the reduction in benefits from the intervention was substantial enough that Time 3 MEPS and anxiety symptomology scores were not significantly improved on Time 1 scores.

Table 28: *Paired-Samples t-tests between Time Points for MEPS and Anxiety Symptomology.*

Variable Pair	Mean	Std. Dev	Std. Error	df	t	Sig. (2-tailed)	95% Confidence Interval	
							Lower	Upper
t1 MEPS t2 MEPS	-2.0	3.183	.796	15	-2.513	.024	-3.696	-.304
t2 MEPS t3 MEPS	1.733	3.369	.870	14	1.992	.066	-.133	1.992
t1 MEPS t3 MEPS	-.063	3.021	.755	15	-.083	.935	-1.673	1.548
t1 Anxiety t2 Anxiety	3.0	2.799	.776	12	3.865	.003	1.309	4.691
t2 Anxiety t3 Anxiety	-.917	2.429	.701	11	-1.307	.218	-2.460	.627
t1 Anxiety t3 Anxiety	1.75	3.079	.889	11	1.969	.075	-.206	3.706

4.11.5. Impact of 'Meetings Attended' on MEPS Retention

To consider why a significant reduction in MEPS was observed from Time 2 to Time 3, the number of meetings participants attended (which is representative of the number of problem-oriented tasks the individual completed) was added into a repeated measures ANOVA as a covariate.

Results from the repeated measures ANOVA did not discover any significant interaction between the number of meetings attended and the change in MEPS scores from Time 2 to Time 3 ($F = .402$, $p = .531$, partial eta = .013).

4.12. Deductive Thematic Analysis on Initial Improvements Identified

Immediately following the completion of the intervention, participants discussed their experiences of taking part in the intervention with each other, discussing what they enjoyed, did not enjoy, and (if given the opportunity) what they would change. All group interviews were then transcribed manually.

A Braun and Clarke (2006) deductive thematic analysis (see Study 5 for more details regarding the procedure) was performed on the transcribed interviews, with two pre-determined themes (based on quantitative findings): (1) improved problem-solving skills; and (2) reduced anxiety symptomology.

4.12.1. Theme 1: Improved Problem-Solving Skills

Participants were able to relate to the problems, which increased their engagement when discussing how to overcome them. For example, Participant D spoke about how she used the information gained from one of the problem-oriented tasks (how to deal with deterioration of eyesight) to manage her own eyesight loss.

> *'The eyesight one really helped me…I mean with that I learned more about what the Institute for the Blind can do, and now I am friends with my iPad. I can zoom in, download pictures off Facebook, and all sorts of things'* - Participant D

Another participant also showed the important of relatability to the problem-oriented tasks, even though she does not have issues with eyesight or hearing, being aware of this information would benefit her in the event these issues begin to appear.

> *'I liked the weeks about hard of hearing and sight, and you mentioned the thing available for people with bad eyesight, where their eyesight had failed them and all that, and I found that very useful because if I'm ever in that position myself and I know there is aids out there to help you.'* - Participant E

Another avenue that appears to have improved problem-solving skills was the exposure to solutions the participants had not previous considered. For example, several participants spoke about how they heard of viable solutions which would not have occurred to them, and they feel they have benefitted from this exposure, even if they do not currently live with the issue that was discussed.

> *'I found some of the solutions to problems we have come across over the past few weeks, it was useful to listen to other people's ideas rather than mine. Mine are rather, straight down'* - Participant F.

> *'I thought it widened our views, of how we look at things, and that was good. We were not confined to our own views'* - Participant G.

Finally, participants also spoke about how the availability of a regular group gave them the platform to talk about their personal issues and how it is affecting them (one week of the intervention was specific to this, participants were given the opportunity to provide a problem they are dealing with and ask other group members how they would tackle the problem).

> *'I think this raises the point of your work, the benefits of having a group, where you don't have to come, and talking about the benefits of erm…about your developments and experiences and problems within the place.'* - Participant B.

'A lot of people living in here (ExtraCare retirement villages), not necessarily us, would benefit from having the discussions we have had over the past few weeks, and perhaps…services etc. can be better explained. This sort of exercise is very good at bouncing off each other etc. etc. and trying to influence how things may go.' - Participant C.

These quotes show a process in which the intervention facilitated the improvement of problem-solving skills. They also support previous findings within the meta-analysis Barnes *et al* (2017) and Belzer *et al* (2002) which showed that the greatest improvements to problem-solving skills were within interventions which utilised problem-oriented tasks within a group setting.

4.12.2. Theme 2: Reduced Anxiety Symptomology

In Study 5, under the theme 'Health in Ageing', robust participants displayed an underlying anxiety when discussing their health. However, this was absent in the discussions by participants who completed the intervention. For example, Participants D and E (from the quotes above) spoke openly about their health issues or risk of future health issues. For instance, Participant D and E spoke about the loss, and risk of losing, their eyesight and hearing did not discuss any concerns about their health, but contentment with their ability to manage their health effectively.

Based on the quotes discussed by Participants D and E, it is plausible that the reduction in anxiety symptomology can be attributed to the availability of a group that allows the participants to discuss about their personal issues, a technique used in group therapy (Beehr, & McGrath, 1991; Krijn, Emmelkamp, Olafssson, & Biemond, 2004), and receive help from

peers. Indeed Participants A and C echo this sentiment, highlighting the benefits of being able to attend a group to discuss problems with others.

> *'Listening to you every week I realised how important it is to have this discussion group, to have it here and not in the Street Meeting, where people probably wouldn't talk about it, but having a small group of people and occasionally discussing things, problems, and issues, I think we benefit, because it is marvellous really.'* - Participant A

> *'A lot of people living in here (ExtraCare retirement villages), not necessarily us, would benefit from having the discussions we have had over the past few weeks, and perhaps…services etc. can be better explained. This sort of exercise is very good at bouncing opinions off each other etc. etc. and trying to influence how things may go.* - Participant C

These findings highlight the importance of group activities, and how they provide the platform for improvements in problem-solving and reduction in anxiety symptomology to occur.

4.13. Discussion

The purpose of this study was to implement and evaluate the intervention designed in Study 5, the focus of which was to build resilience by improving problem-solving skills in participants recruited from ExtraCare retirement villages.

Pre- to post-intervention analyses showed a significant improvement in problem-solving skills and anxiety symptomology. However, this did not translate into a significant improvement in resilience. There was also no improvement in depressive symptomology, feelings of loneliness, perceptions of environmental age-friendliness, or quality of life. However, as there was no significant improvement to resilience, this was expected. Finally, initial improvements identified in problem-solving skills and anxiety symptomology were not maintained at the follow-up assessment.

Attempts at understanding the deterioration in problem-solving skills did not produce meaningful findings. The number of meetings attended (and thereby the number of problem-oriented tasks completed) was considered as a covariate as increasing more problem-oriented tasks has shown to increase problems-solving skills (Barnes *et al.*, 2017), and therefore it was considered that this may also aid in the maintenance of problem-solving skills too. This was, however, incorrect as the number of meetings attended did not significantly impact on the retention of problem-solving skills. There are two alternate possibilities for this deterioration: (1) the problem-oriented tasks used in the resilience-building intervention were health-focussed, whereas the assessment of problem-solving skills (the mean-ends problem solving assessment) utilised social problems to assess problem-solving skills. Therefore skills learned may not have been directly transferable. However, if this theory was accurate, it is also likely that meaningful improvements in problem-solving skills would not have been observed from pre- to post-intervention. (2) The retention of problem-solving skills requires a continuation of problem-solving following the completion of the programme, and at this point participants reverted to activities that did not actively require problem-solving skills. If this is correct, it would account for the difficulty in observing long-term benefits in problem-solving interventions discussed by Barnes *et al* (2017). That is, for an intervention to effectively improvement problem-solving skills on a long-term basis, it must incorporate a component of

behavioural change, or incorporate tasks on a long-term basis to maintain participants actively engaging in problem-solving activities.

In relation to resilience, it is plausible to attribute the decrease in resilience to participants being subjected to a new stressor. Indeed, Seligman (2007) argued as such, that being subjected to a new stressor is likely to reduce resilience. Despite findings evaluating this not being significant, it is possible to attribute this to the small sample size available for analysis, as inferences can be made from the non-significant findings that support Seligman (2007).

Similar to problem-solving skills, anxiety symptomology also increased to near pre-intervention levels at the follow-up assessment. In the thematic analysis it was identified that the availability of a regular group meeting in which participants are given the opportunity to discuss their feelings and concerns with others that provided the initial reduction in anxiety symptomology. Indeed, similar designs are used specifically to reduce general anxiety (Dugas *et al.,* 2003; Kim *et al.,* 2010; Yang, & Clum, 1994). However, upon the completion of the intervention, the groups disbanded, and therefore the opportunity to discuss issues and concerns was no longer available.

In considering the importance attributed by participants to the completing the activities in groups, it was surprising that no significant improvement to feelings of loneliness was observed. Indeed in the qualitative thematic analysis, participants rarely referred to the social support benefits of completing the intervention in a group setting. Yet, in many of the groups (6 of the 9 groups) participants were familiar with one another, if not already close friends. Therefore, the capacity to build new social ties, and therefore reduce feelings of loneliness, was limited.

4.14. Limitations

The ceiling and floor effects presented a substantial issue which resulted in the removal of the assessment of 'feelings of exhaustion' as an outcome, and significantly reduced the sample strength of several outcome variables. Although the official ceiling effects (i.e. maximum scores) were removed from the analysis, scores immediately below maximum scores were retained, which presented limited capacity to show improvement by taking part in the intervention. Whilst participants did emphasise the importance of the intervention, the ability to draw meaningful quantitative conclusions regarding the effectiveness of the intervention was limited.

4.15. Conclusion

The purpose of the study was to implement and evaluate the intervention designed to build resilience by improving problem-solving skills. This was partially achieved, as participants problem-solving skills did significantly increase following the completion of the intervention, although benefits were not maintained. Furthermore, this did not translate into a building of resilience, although Seligman (2007) argues that for this to occur, participants need to be exposed to, and overcome, a stressor. The intervention also did not produce any long-term benefits. It can be concluded that the intervention is capable of improving problem-solving skills on a short-term basis, but further adjustments are necessary to maintain improvements on a long-term basis. In addition, further long-term assessments are required, until participants experience and overcome a stressor, to determine if improving problem-solving skills effectively translates into the building of resilience.

Chapter 5

General Discussion

5.1. General Discussion

5.2. Summary of Background and Aims

Resilience and frailty are viewed as polar opposites along the same dimension i.e. to be resilient is to not be frail and vice versa (Rockwood, & Mitnitski, 2015). Resilience is also conceptualised as a physiological construct (Herrman *et al.*, 2011), despite recognition of resilience in other contexts being multidimensional (Cosco *et al.*, 2017). It is plausible this is a reflection of the focus on defining and analysing frailty through physiological means. However, conceptualising resilience solely as a physiological preventative measure fails to account for the psychological components of resilience and the impact they have (Holland *et al.*, 2018) or the key characteristic of resilience to recover from adversity (Christiansen, 2011).

A theory more representative of the whole construct of resilience is that suggested by Cosco *et al* (2017) who stated that resilience is a multidimensional construct that acts as both preventative measure and response mechanism. This theory was supported by Holland *et al* (2018) who provided evidence towards the benefits of maintaining resilience despite the presence of frailty. Yet fundamental questions remain as to what resilience is and how we conceptualise it in relation to frailty. Indeed Holland *et al* (2018) stated that despite their findings, further research was required into examining this relationship. However, without a validated holistic frailty index, we are unable to fully assess this relationship, and attempts at developing a multidimensional tool (such as Peter's (2012) Groningen Frailty Index and Gobben's (2011) Tilburg Frailty Indicator) lack the level of validation required of a frailty index (Dent *et al.*, 2016).

These findings highlighted the limitations of our conceptualisation of resilience in the context of frailty, as well as the measures available to consider this relationship. Therefore, the aim of the current project was to develop and validate a frailty index towards a holistic model, and to

utilise that model to assess how we conceptualise the relationship between resilience and frailty.

5.3. Principal Findings

5.4. The Frailty Index

In Chapter 1, we identified the limitations of multiple indices and presented a case emphasising the need for a holistic frailty tool. We also identified Holland *et al*'s (2015) Frailty Index as the optimal tool for developing into a holistic tool, and projected a pathway in which this could be completed. In Chapter 2, three studies were completed to achieve this goal. In Study 1, Holland *et al's* (2015) Frailty Index was refined into a 52-item model by removing current variables within the tool, and adding new ones. This included removing the variable 'falls' as a predictor, and instead considering it as an outcome of frailty (Clegg *et al.,* 2013), and adding in an assessment of exercise frequency and polypharmacy (the taking of four or more prescribed medications) to represent the assessment of physical activity in the Frailty Phenotype (Fried *et al.,* 2001), Rockwood's (2005) CSHA Frailty Index, and Clegg's (2016) electronic Frail Scale. An additional variable was added, a 'joint effect' variable. The purpose of this variable was to address the increased impact of a specific comorbidity (Coronary Heart Disease and Diabetes), which has shown to produce additional adverse impact on health when both illnesses are present compared to the individual impact of either illness. This variable also provided the opportunity to address the imbalance between markers, an issue associated with the accumulation of deficits approach (Rockwood & Mitnitski, 2007), with attempts at addressing this imbalance via weighting compromising the generalizability of the model (Song *et al.,* 2014). Following these adjustments, the refined Frailty Index was re-validated. The refined Frailty Index possessed high reliability and validity, comparable to Fried's (2001) Frailty Phenotype and Rockwood's (2005) CSHA

Frailty Index, and was also able to predict the need for social care over a 2-year period, the benefits of which are apparent. More importantly, these findings provided evidence that a frailty index can possess a large psychological contingent and possess similar levels of validation when compared to clinically used models.

In Study 2, we considered the limitations identified in Study 1 directly relating to the structure of the tool (such as time requirements), and subsequently shortened the index to a 36-item model, which retained reliability and validity levels similar to the 52-item version. Furthermore, the predictive capabilities of the 36-item Frailty Index was comparable to, if not better than, multiple frailty indices. Initially, Rockwood, and Mitnitski (2007) stated that for a frailty under using an accumulation of deficits approach to be valid and reliable, it must contain a minimum of 40 markers. However, the conclusions from Study 2 challenge this assumption as validity and reliability of the 36-item model was comparable to the 52-item version. We postulate that this is because the items within the 36-item model uniquely contribute to frailty (as determined by their retention through the PCA, and there being no item redundancy present following the variable reduction process). Therefore, it is plausible that an accumulation of deficits frailty index can possess high validity and reliability with fewer than 40 variables within the model, but the items used must uniquely contribute to the model, such as by improving the predictive capabilities of the model.

The third and final study aimed to develop the 36-item model further into a holistic frailty tool by incorporating a psychosocial and environmental frailty marker into the tool. Previous attempts at this have produced inconsistent results. We postulate that this is partially attributable to there being no acceptable definition of psychosocial and environmental frailty. Indeed, as noted in Chapter 1, there are multiple definitions used across indices, and each index that attempts to evaluate psychosocial and environmental frailty does so with markers unique from the other indices, with the assessment of loneliness being the exception.

Following the evaluation of the literature regarding psychosocial and environmental frailty, two candidate items were identified (one for each dimension): loneliness and perceptions of environmental age-friendliness and the purpose of Study 3 was to determine if their inclusion into the 36-item Frailty Index was justified. This was done based on conclusions from Study 2 i.e. that the two items should correlate with frailty, and also uniquely contributed to the model.

It was confirmed that both loneliness and perceptions of environmental age-friendliness are unambiguously associated with frailty, and that each item uniquely contributed to the model (with loneliness significantly predicting quality of life, and perceptions of environmental age friendliness significantly predicting quality of life and the amount of formal care received, whilst controlling for frailty). This presents a pathway in which further psychosocial and environmental frailty markers can be identified. That instead of attempting to define these dimensions and subsequently identify markers to fit the definition, to instead identify markers associated with frailty through analytical means and then determine how to define these dimensions based on the markers identified and their relationship with frailty.

5.5. The Relationship between Resilience and Frailty

Study 4 evaluated the relationship between psychological resilience (defined as a process of coping and adaptation, Cosco *et al.*, 2017) and frailty. This process involved considering if resilience significantly predicted measures used to assess frailty to determine the validity of Rockwood and Mitnitski's (2015) conceptualisation that resilience and frailty are polar opposites along the same spectrum (significant findings would support this conceptualisation). Following this, the study evaluated what frailty outcomes were associated with resilience (whilst controlling for frailty), and if resilience moderated the predictive strength of frailty in predicting these outcomes.

Evidence for and against Rockwood and Mitnitski's (2015) assertion was produced. Psychological resilience had shown to significantly predict feelings of loneliness, perceptions of environmental age-friendliness, depressive symptomology, and feelings of exhaustion. Therefore, if resilience scores increased, it is plausible to conclude that improvement in these assessments would also be observed. Therefore, resilience may have a direct impact on frailty. However, resilience only predicted a minority of the assessments used to evaluate frailty severity, most of which are non-physiological markers; although it is likely that physiological resilience may predict many of these markers. Yet even when focusing solely on non-physiological assessments, resilience predicted four of the six assessments used. Furthermore, two of the assessments predicted are either rarely used in other indices (loneliness) or exclusive to the 38-item model used in this thesis (perceptions of environmental age-friendliness). Therefore, the effect of psychological resilience on frailty is likely to vary depending on the index used to evaluate frailty severity. This means that resilience should be considered to have a direct impact of frailty, but not the polar opposite of frailty.

In considering the impact of psychological resilience on frailty outcomes (while controlling for frailty), it was concluded that psychological resilience significantly predicted anxiety symptomology and quality of life. It is plausible to attribute these findings to the greater levels of problem-solving skills and social support associated with high resilience (as discussed in Chapter 1). For instance, greater levels of social support provide individuals the opportunity to discuss their issues and feelings with peers and receive guidance from friends. Subsequently, this provides individuals with a sense of belonging (Choenarom, Williams, & Hagerty. 2005), and resources when dealing with stressors such as bereavement (Logan *et al.*, 2018). This results in greater quality of life, and reduced feelings of anxiety and depression (Beehr, & McGrath, 1991; Choenarom *et al.*, 2005; Helgeson, 2003). Alternately, greater and more effective problem-solving skills increases the likelihood that positive problem-focused coping strategies are implemented when faced with a stressor (Bell, & D'Zurilla, 2009),

which is shown to have a beneficial impact on feelings of anxiety and depression, (Bell, & D'Zurilla, 2009; Khoori, Zareki, Mohammedkhani, Ghaseminejad, & Seyedghasemi, 2018). Improvements in these outcomes are also associated with increased self-efficacy and feelings of optimism about overcoming potential future stressors (Cunningham, Lockwood, & Cunningham, 1991; Tahmassian, & Moghadam, 2011; Vilhena *et al.*, 2014; Zenger, Brix, Borowski, Stolzenburg, & Hinz, 2010).

The potential moderating effect of resilience on frailty was considered in Chapter 1. For instance, qualitative evidence provided by Holland *et al* (2018) showed that individuals who were frail but resilient were able to maintain an enjoyable lifestyle and continue engaging with their leisurely activities. Alternately, D'Avanzo *et al* (2017) provided substantial evidence surrounding how resilient (but frail) individuals implement strategies and procedures in an attempt to maintain their functionality. These examples can be mapped to assessments of quality of life and perceptions of functional limitations. Yet, resilient did not display any moderating effect in relation to these two, or any other, outcomes. In relation to physiological outcomes (i.e. perceptions of functional limitations, formal care, falls, and hospitalisation) this was expected. As previously discussed, it was unlikely that psychological resilience would predict physiological assessments of frailty, and therefore it is reasonable to conclude it is also unlikely that psychological resilience would moderate frailty predicting physiological outcomes. It was, however, unexpected that resilience did not moderate the predictive strength of frailty in predicting outcomes such as anxiety and depressive symptomology, as well as quality of life. It is possible that this is due to the majority of assessments used to evaluate frailty severity in the FI38 being assessments of physiological frailty (60%). Therefore, a more accurate representation of the effects of psychological resilience on frailty may have been achieved if the evaluation between these two constructs was completed with frailty being assessed solely from a psychological perspective.

The multiple conceptualisations regarding the role of resilience in the context of frailty has resulted in a lack of clarity in relation to how we should objectively define resilience. Rockwood and Mitnitski (2015) argue resilience is the opposite of frailty, and conceptualise it as a physiological construct. Alternately, Holland *et al* (2018) discuss the notion of being resilience despite the presence of frailty, and emphasise the importance of psychological resilience. Varying benefits are also attributed to maintaining high resilience within each context (such as robustness in Rockwood's conceptualisation, and quality of life in Holland's) of maintaining high levels of resilience.

As findings from Study 4 provide supportive evidence for both conceptualisations, we argue that both conceptualisations possess merit, and are therefore incomplete. For instance, Rockwood and Mitnitski (2015) fail to consider the key component of resilience regarding the capacity to regain lost functioning (which would translate as becoming robust once categorised as pre-frail, or frail), and Holland *et al* (2018) described the role of psychological resilience when physiological capabilities are reduced, failing to consider the role of psychological resilience when physiological resilience is still present.

Based on these models, and the evidence discovered in Study 4, we suggest that resilience, whilst closely associated with frailty, is a separate but interrelated construct, and that different components of resilience take priority depending on frailty severity.

If we consider these two conceptualisations along a frailty spectrum, it is likely that physiological resilience is the primary form of resilience whilst the individual is considered robust. Yet, as physical capabilities deteriorate, the primary form of resilience begins to transition from physical to psychological, and at the point the individual's ability to physiologically adapt is compromised, psychological resilience becomes the main form of resilience adopted.

There are, however, several questions that remain. For instance, whilst it is reasonable to conclude that as physical capabilities deteriorate, a transition of importance from physiological to psychological frailty is expected, but we remain uncertain as to when this transition begins. In addition, we state that the necessity to psychologically adapt becomes more prominent when physical capabilities diminish, but at what point of frailty progression would we expect to see the capacity to psychologically adapt diminish? We can hypothesise that the diminishing of psychological frailty would be associated with near end-of-life outcomes (such as institutionalisation and death), but evidence is lacking to produce meaningful conclusions. Furthermore, we consider early intervention vital in preventing frailty progression, but if, as Hale, Shah, and Clegg (2019) state, we can consider improving resilience as a viable method for responding to, and reversing frailty, then the capacity for intervening on frailty progression should be feasible until the ability for the individual to respond to adversity and adapt is compromised? These queries, as well as the validity of the model outlined, should be considered in future research.

5.6. The Resilience-Building Intervention

With the benefits of improving and/or maintaining high psychological resilience despite the presence of frailty confirmed. The final stage of this project was to design, implement, and analyse the effectiveness of a resilience-building intervention. The design process was completed through a dual approach of co-creation and feasibility considerations with stakeholders' representative of the target population.

Prior to implementing an intervention, it is common for a pilot study to be conducted first, feedback is received from participants and subsequent changes are made to the intervention based on the feedback (Arian *et al.*, 2010). The purpose of implementing a process of co-creation and considerations of feasibility with stakeholders was to forego the necessity for a

pilot study. That is, if participants significantly input into the development and feasibility considerations of the intervention, the need for a pilot study is negated (Voorberg *et al.*, 2015). This provided two benefits. Firstly, this process was more time efficient than implementing a pilot study. For instance, not factoring in recruitment and data collection and analysis, the pilot study would take 12 weeks to complete based on the original design (see Study 5), whereas the co-creation and feasibility processes were completed within four weeks. Secondly, upon completing the pilot study, participants are given a single opportunity to provide feedback, yet the process of co-creation allowed for participants to provide feedback, review changes and provide further feedback, thereby refining the intervention in a manner not typically achievable with a single point of feedback. This process of refinement is also shown to increase representativeness to the target population (Sanders, & Stappers, 2008). Indeed, when participants discussed the intervention (see Study 5), representativeness to the target sample was apparent. These findings highlight the benefits of incorporating stakeholders into the design process of an intervention.

From a methodological perspective, the option to utilise a 'delayed intervention' condition as opposed to a standard control condition was for two reasons. Firstly to strengthen the sample size; based on power analyses performed prior to recruitment it was estimated that 34 participants would be required to draw meaningful conclusions from analysis on a pre- post-intervention comparison, although the actual sample target was 40 participants to account for participant attrition. Therefore to reduce the burden on recruitment utilising a delayed intervention condition allowed for a sufficient number of participants to complete the intervention and each condition act as the control for the other. Secondly, as we were expecting this intervention to improve the mental health of participants, we have ethical considerations to ensure all participants receive this benefit.

Based on findings in Chapter 1, the intervention utilised problem-solving skills as the primary form of building resilience in participants. This pathway has consistently been identified

(Dumont, & Provost, 1999; Prati, & Pietratoni, 2009; MacLeod *et al.,* 2016) and effectively implemented in multiple settings (Barnes *et al.,* 2017). However, facets associated with social support, optimism, and self-efficacy was also incorporated into the intervention to produce a multidimensional approach within the intervention to resilience-building. For instance, to build social support and strengthen social ties between participants the intervention was completed in groups in an informal setting where participants got to share their experiences with one another (Cohen-Mansfield *et al.,* 2018). To help improve feelings of optimism within participants when faced with health-related problem, the hypothetical scenarios all ended with an ideal outcome for the individual. It is plausible therefore that having participants engage in problem-solving with an ideal outcome as the goal may improve participant orientation towards problems by thinking of the ideal outcome and devising strategies to achieve it (Hamm, Perry, Chipperfield, Parker, & Heckhausen, 2019; Segerstrom, Carver, & Scheier, 2017). Finally, receiving positive feedback about suggestions towards solutions to problems (participants were instructed that there are no right or wrong answers to problems, just different solutions to a problem) from group members can have a beneficial impact on feelings of self-efficacy (Bandura, 1977; Karl, O'Leary-Kelly, & Martocchio, 1993; Schunk & Di Benedetto, 2016). Although we did not directly assess self-efficacy, Keye, and Pidgeon (2013) found a substantial correlation between the CD-RISC10 and self-efficacy ($r = .65$, $p<.001$), and therefore evaluating self-efficacy directly was not considered necessary

Participants displayed a significant increase in problem-solving skills and a reduction in anxiety symptomology as a consequence of completing the intervention. However, these improvements were not maintained at the follow-up assessment. The lack of long-term benefits is an issue previously cited by Barnes *et al* (2017). One possibility for this is that the improvement in problem-solving skills is facilitated by completing problem-oriented tasks, but once the intervention is complete, participants complete fewer problems compared to

when they completed the intervention. Therefore, to maintain benefits an intervention may need to integrate problem-solving activities into participants' hobbies.

In Chapter 1 it was concluded that improving problem-solving skills was the optimal method for improving resilience (Dumont, & Provost, 1999; Prati, & Pietratoni, 2009; MacLeod *et al.,* 2016). However, whilst we did improve problem-solving skills in Study 6, no meaningful change in resilience was observed. It is, however, plausible to attribute this to issues within the sample. For instance, ceiling and floor effects were a significant issue within Study 6 to the extent that 50% of participants displayed ceiling effects regarding perceptions of loneliness, and feelings of exhaustion was removed from analyses completely. Although resilience was classified as having no ceiling effects (with only 12.8% of participants possessing the maximum resilience score of 40, short of the 15% required to consider a variable possessing ceiling effects, Terwee *et al.,* 2007), 25.9% of participants scored $\geq$38 in their resilience assessment, and therefore offered little scope for meaningful improvement. Wang *et al* (2008) suggested that if ceiling effects are observed, listwise removal of data should be implemented, or the ceiling effect scores be coded as 'missing data'. Yet, implementing either method can reduce the sample strength (as was observed in Study 6) and reduce the capacity to draw meaningful conclusions from analyses. Therefore, we are unable to assess the effectiveness of improving problem-solving skills as a suitable pathway for building resilience in older adults.

These findings indicate that on a short-term basis, the intervention is effective in improving participants' problem-solving skills. However, further development is required to consider how to maintain these benefits on a long-term basis. Further research is also required to determine how well the intervention improves resilience.

5.7. Limitations and Future Directions

Chapter 2 focused on refining Holland *et al's* (2015) Frailty Index and developing it into a holistic frailty tool. Whilst there is a large psychological contingent in the tool, psychosocial and environmental frailty remains underrepresented in assessment. We can attribute this to there being a lack of unambiguous markers (beyond what has been identified in this thesis) associated with psychosocial and environmental frailty. Yet, more effort is required in developing our understanding of these dimensions. Once identified, markers should be considered for inclusion within the holistic frailty tool. However, we must also be cautious regarding the time requirements of completing an assessment impacting the usability of the tool.

We also highlighted the benefits of incorporating 'joint effects' into the tool, and how this can provide more weight to severe health conditions (such as was attributed to Coronary Heart Disease and Diabetes in the FI52) without compromising the generalizability of the model. Yet only a single joint effect has been identified, and therefore we should consider potential new joint effects to further improve the importance of more severe health conditions assessed within frailty assessment. Whilst completing such a task would not increase time requirements in completing the assessment, it would, however, begin to move the model further away from Rockwood's (2005) accumulation of deficits approach.

Chapter 3 evaluated the relationship between psychological resilience and frailty. It was concluded that resilience may have a beneficial impact on frailty directly, and outcomes associated with frailty. However, it is plausible that we underrepresented the impact of resilience on frailty by considering frailty from a holistic standpoint. For instance, the assessments of frailty that psychological resilience predicted were all in relation to non-physiological frailty markers. Therefore, perhaps a fairer comparison would be to consider the effects of psychological resilience on psychological frailty.

Chapter 4 implemented and evaluated the effectiveness of a resilience-building intervention. Whilst results were inconclusive, there was substantial ceiling and floor effects observed which significantly reduced our capacity to assess outcomes and draw meaningful conclusions from analyses.

Future research should aim to address these issues outlined. Firstly, to unambiguously identify more psychosocial and environmental frailty markers, and consider their integration into frailty assessment; and secondly to provide a more representative assessment of resilience in relation to frailty. This should involve evaluating the impact of physiological resilience on physiological frailty, and psychological resilience on psychological frailty. Following this, more meaningful conclusions regarding the role of resilience in the context of frailty can be made. Finally, to reconsider the effectiveness of the resilience-building intervention and to identify potential methods in which benefits of completing the intervention can be maintained on a long-term basis.

5.8. Conclusions

The aim of the current thesis was to assess the impact of maintaining high levels of resilience on frailty and outcomes associated with frailty. We considered the available conceptual models of resilience and frailty, determined their validity, and identified gaps within the literature that required addressing. We also considered the suitability of current frailty indices to assess this relationship. From this review we redefined and developed a frailty index into a holistic tool and used this to assess the relationship between psychological resilience (defined as a process of coping and adaptation) and frailty. Finally, a resilience-building intervention was developed, implemented, and evaluated.

From the findings assessing the considerations outlined, it can be concluded that we produced a valid, reliable, and holistic frailty tool. We can also conclude that resilience should be

considered more than the polar opposite of frailty, but rather a separate but interrelated construct that can directly improve frailty, as well as frailty outcomes. We should also incorporate psychological resilience into our conceptual models of resilience in the context frailty. However, further research is required to determine the effects of resilience across the spectrum of frailty (from robustness to frail and end of life). We must also consider how to improve and maintain resilience in older adults on a long-term basis.

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Appendix B: Variables Assessed in the CSHA Frailty Index

Changes in everyday activity	Mood problems	Seizures, partial complex
Head and neck problems	Feeling sad, blue, depressed	Seizures, generalized
Poor muscle tone in neck	History of depressed mood	Syncope or blackouts
Bradykinesia, facial	Tiredness all the time	Headache
Problems getting dressed	Depression (clinical impression)	Cerebrovascular problems
Problems with bathing	Sleep changes	History of stroke
Problems carrying out personal grooming	Restlessness	History of diabetes mellitus
Urinary incontinence	Memory changes	Arterial hypertension
Toileting problems	Short-term memory impairment	Peripheral pulses
Bulk difficulties	Long-term memory impairment	Cardiac problems
Rectal problems	Changes in general mental functioning	Myocardial infarction
Gastrointestinal problems	Onset of cognitive symptoms	Arrhythmia
Problems cooking	Clouding or delirium	Congestive heart failure
Sucking problems	Paranoid features	Lung problems
Problems going out alone	History relevant to cognitive impairment or loss	Respiratory problems
Impaired mobility	Family history relevant to cognitive impairment or loss	History of thyroid disease
Musculoskeletal problems	Impaired vibration	Thyroid problems
Bradykinesia of the limbs	Tremor at rest	Skin problems
Poor muscle tone in limbs	Postural tremor	Malignant disease
Poor limb coordination	Intention tremor	Breast problems
Poor coordination, trunk		Abdominal problems
Poor standing posture	History of Parkinsons disease	Presence of snout reflex
Irregular gait pattern	Family history of degenerative disease	Presence of palm omental reflex
Falls		Other medical history

Appendix E: Variables used in the electronic Frailty Index

Activity limitation	Memory and cognitive problems
Anaemia and haematinic deficiency	Mobility and transfer problems
Arthritis	Osteoporosis
Atrial fibrillation	Parkinsonism and tremor
Cerebrovascular disease	Peptic ulcer
Chronic kidney disease	Peripheral vascular disease
Diabetes	Polypharmacy
Dizziness	Requirement for care
Dyspnoea	Respiratory disease
Falls	Skin ulcer
Foot problems	Sleep disturbance
Fragility fracture	Social vulnerability
Hearing impairment	Thyroid disease
Heart failure	Urinary incontinence
Heart valve disease	Urinary system disease
Housebound	Visual impairment
Hypertension	Weight loss and anorexia
Hypotension/syncope	
Ischaemic heart disease	

Appendix G: Resilience-Intervention Template

The intervention will take place over a 12-week period, with participants completing one task a week, which will be completed over an hour. This duration was chosen as participants would only require a small time commitment on a regular basis that can fit into their weekly routines. The intervention will be completed in groups of four to six. This is designed to ensure that each participant has sufficient time to give their opinion about the problem. This also reduces the likelihood that participants may not wish to take part in case they lack confidence to talk in larger groups.

The weekly activities will consist of:

1. One group introduction task (Week 1). Participants use the first week of the programme to introduce themselves to each other.
2. Eight problem-solving tasks (Weeks 2, 3, 5, 6, 7, 9, 10, and 11). This amount was based on research by D'Zurilla and Goldstein (1971), who thought that eight problem-solving tasks is the minimum required to see meaningful improvement in problem-solving skills.
3. A social event task (Week 4) designed to improve relations between the participants and help create a more informal environment.
4. A skills acquisition task (Week 8). In this task participants are tasked with considering a skill they could learn, how they could learn this skill, and how it would benefit their everyday life.
5. The final task (Week 12) is a group discussion. Participants will provide discuss their experiences of completing the intervention. A total of three questions are asked in a semi-structure setting with further questioning based on their answers. The questions are:
    a. What was your experience of taking part?
    b. If you could change part of the intervention, what would it be and why?
    c. Is there anything that you think would stop people from taking part?

Appendix H: Topic Sheet

Question	Prompts
Introductions	**As part of the introduction participants debriefed on the purpose of the study, what their role will be in terms of shaping the programme, and are given a copy of the intervention template to review.**
Intervention Template	
Amendments	Having reviewed the intervention template, are there any concerns you have? Is there anything you would change?
Group Introduction Activity	
Design	What do you think is a good way for people to introduce themselves in the group? If you were taking part, what would you do to introduce yourself to a group of people you do not know?
Problem-Solving Skills	
Everyday problems	**In discussing the use of problem-solving skills** Do you think that residents would be happy to solve problems on a weekly basis? Can you tell me about the things you deal with in everyday life around the village? Or see common issues around the place? **If a common theme amongst problems is observed** Aside from *insert common theme* issues, what other issues do you think are prevalent in

	the village? For example, loneliness? Or practical problems such as travelling around the community. *AND/OR* Some of the other groups have noted **insert issue** is frequently cited in their village, is this something you see here?
Group Size	
Total numbers per group	How many people do you think we should have in a group, and why?
Duration	
Intervention duration	As you know the programme is designed as a 12-week problem, can you think of any issues this may cause? How can we overcome these issues?

Appendix I: Resilience-Building Intervention

Week 1

Getting to Know your Teammates

The activity for Week 1 is to get to know your team, who you will be working with over the next 11 weeks.

As part of a get-to-know-you exercise, you will be tasked with telling the group about yourself.

Week 2

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

During a walk, you have a fall and injure your leg. After your leg has healed, you find you lack the fitness to go on long walks, and also worry you would injure yourself again if you did.

You are confident that you can go for walks without injuring yourself, and have the fitness to go on walks once again.

Week 3

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

You live alone in your apartment. Your sight has gotten worse and it is difficult to maintain your apartment. You often walk into tables and break things, it is difficult to tell the time so you do not know when to take your medication.

Although your sight is not getting better, you are able to maintain your apartment. You do not walk into tables and accidentally break your possessions, and you are able to manage your medications well.

Week 4

The activity for this week's socialising event will be decided by the group. Consider what events are available to do within the village, or anything the group might be able to do outside the village such as going to the theatre, on a long walk, or any other activity that may interest you all.

If there is not much that appeals, quite simply spending time together in the communal area with tea & coffee socialising is also fine.

Week 5

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

You own a car and like to drive to the shops and to visit friends and family. Due to medical reasons, you have to give up driving, but in doing so you are unable to travel to the shops, and family and friends live too far away to visit.

Although you cannot drive anymore, you can still do all your shopping, and visit friends and family without any issues.

Week 6

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

You often spend time with friends who live near you. However, you have to move away and now rarely get to see your friends. Because of this you often feel isolated from people in your new community and lonely.

You are able to still see your old friends on occasion, you have made new friends who live near you, and you no longer feel isolated or lonely.

Week 7

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

You notice that you are more forgetful of things than you used to be. You sometimes forget to take medication, forget appointments, and forget arranging visits with friends and family. This causes you feelings of anxiety and worry.

You are still forgetful on occasion, but you do not forget important things like to take medication, appointments, or visits with family and friends, and you no longer feel anxious or worried about your memory. You also have arrangements in place to remind you in case you forget anything.

Week 8

The activity for this week is thinking about how to learn a new skill. Think of a skill that you would like to learn, how you would learn this skill, and how learning the skill would help your everyday life.

If you were to learn a new skill, what would it be?

How would you learn this skill?

How would this skill help your everyday life?

Week 9

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

Your well-being advisor has suggested that you are underweight, have a weak grip strength, and are at risk of Osteoporosis.

Your well-being advisor is happy with your current weight and muscle strength, and does not think you are at risk of Osteoporosis.

Week 10

Below is a story that is not finished, with only a beginning and an ending. Using your imagination, please finish the middle part of the story in the space provided.

You live with your partner. You like to spend a lot of time engaging in activities within your community such as going the gym, and playing pickleball. Your partner's health has worsened over the past 12-months. You have to spend more time attending to your partner's needs, which has left you with little time to engage in activities you enjoy. This has also led to a worsening in your own health.

Your partner's needs are sufficiently attended to and you are able to take part in activities you enjoy. Your health has also improved.

Week 11

Talk with your partner a problem of your own for them to solve. If you are happy, the problem will be talked about in the group. If you don't want to do this, you can think of a fake problem for your problem to solve.

What was the Problem your partner discussed?

What was your partner hoping to gain by you solving the problem?

What solutions did you think of?

The programme is now complete. Congratulations!

Now spend 10-15 minutes discussing with each other what you gained from the programme, what you like, dislike, and what you would change.

Appendix J: Participant Recruitment Poster

The ExtraCare Charitable Trust

Aston University

Aston Research Centre for Healthy Ageing (ARCHA)
-Resilient against Frailty

Are you interested in taking part in Healthy Ageing Research?

If so, you can take part in the resilience-building project happening in your very own retirement village!

This project is all about helping residents' better cope with everyday life issues.

This study has been reviewed and received a favourable opinion from the School of Life and Health Sciences Ethics Committee at Aston University

What will it involve?

This project takes place over a 6-month period. You will take part in a 11-week program in which you will get to know residents in your village better and take part in a variety of activities designed to help you better cope with everyday issues. You will also complete assessments on three occasions so we can see what improvements are being made.

Benefits

You will learn about how to deal with everyday issues that may arise in the future.

You will get to meet new residents and build new friendships.

How do I get involved or find out more?

You can email the Aston University research team (Ian Garner) at the email:

[redacted]

1/10/18 version 1.0

Appendix K: Participant Information Sheet

PARTICIPANT INFORMATION SHEET

Study Title: Resilient against Frailty: A Resilience-Building Intervention for Older Adults

Why have I been invited?

You have been invited to take part in this study as you live in an ExtraCare retirement village.

What is this study?

This study is a collaboration between Aston University and ExtraCare to help improve ExtraCare residents' psychological resilience.

What will I be asked to do?

You will be asked to complete a series of assessments on three occasions over a 6-month period (this will involve a series of questionnaires and testing your walking speed and how long it takes you to stand up, general health and well-being, and at one assessment point a short recorded interview).

You will also take part in a group program over 11 weeks with 5 other residents in your village. In this program you will meet up once a week for 1 hour in your groups and discuss your weekly activity (which is provided in your activities booklet that you can view fully before agreeing to take part). Weekly activities involve getting to better know your teammates, considering how to overcome hypothetical problems such as how to overcome having a fall, eyesight getting worse, and how to meet and make new friends), and engaging in group social activities. When appropriate, you will be work in pairs with a member of your group (which will change each week) to consider solutions for the weekly activity.

What if I decide to withdraw from the study?

You possess the right to withdraw from the study at any point without giving a reason. If you wish to withdraw from the study your care/work conditions will not be affected in any way.

What will you do with my information?

Your information will be kept on a password-protected computer for the sake of liaising with you to arrange meetings for assessments and provide information regarding the program.

What happens next?

If you are happy to take part in the study, a fixed weekly time slot will be confirmed for the 11-week program. For your assessments a time slot will be determined based on a time that is most convenient to you.

What are the possible benefits of taking part?

You will get to meet residents of the retirement village, build new relationships and make new friends. Research has also shown that people who take part in similar activities to this intervention improve their coping skills, so you may also have better coping skills after the intervention and be better suited to deal with issues that may arise in the future.

What are the risks of taking part?

You will be asked to consider solutions to problems that are designed to be age appropriate. Therefore it is possible you may previously or currently had to deal with a problem that will be discussed which may cause distress. In the unlikely event you feel distress from taking part in the study it is recommended to consult with the Well-Being Advisor with regards to any issues you may have.

Will my taking part in the study be kept confidential?

Your participation as a stakeholder in the study will be kept confidential at all times with the exception of members of your group and the well-being advisor, who will help with the allocation of residents into groups depending on the amount of people taking part.

What if there is a problem and who do I contact if there is?

If you have any concerns about the way in which this study has been conducted you should contact the Director of Governance, [redacted].

What about if I don't want to participate?

This will not affect your care and/or working conditions or any future interest you may show in Aston University events in any way. You are free to withdraw from the study at any time without giving a reason.

Where will the program take place?

The program will be run within ExtraCare villages, the specific location of the meeting will depend on room availability, and living and work arrangements of participants who agree to take part in the study.

Who has reviewed the study?

This study has been reviewed and received a favourable opinion from the School of Life and Health Sciences Ethics Committee at Aston University

Further information and contact details

For further information about the research: Mr. Ian Garner, [redacted], [redacted].